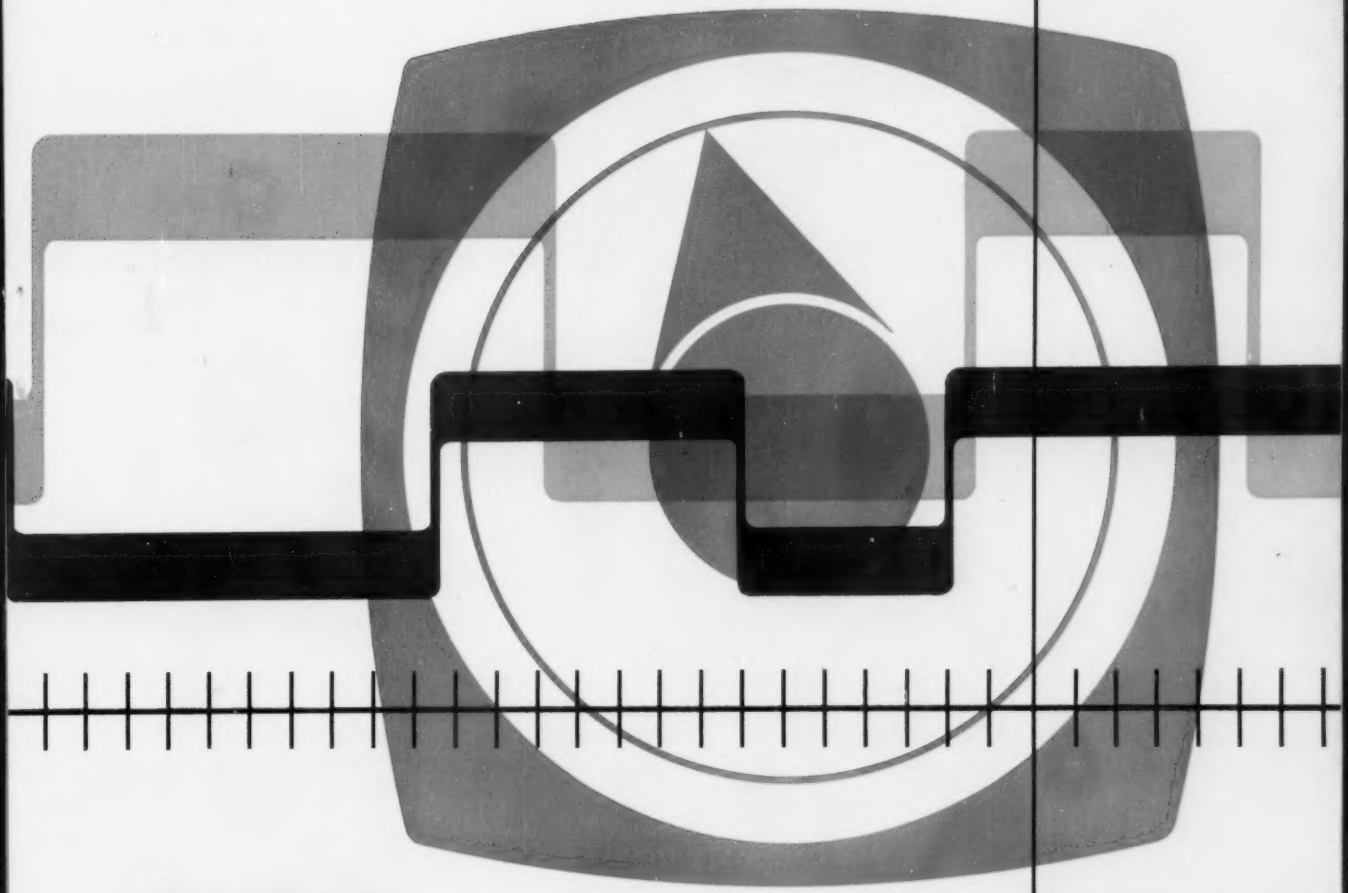
SEPTEMBER 1, 1960

MACHINE DESIGN

A PENTON PUBLICATION — BIWEEKLY



TIMERS

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Mr. Stevens Rice
University Microfilms
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FARNSWORTH

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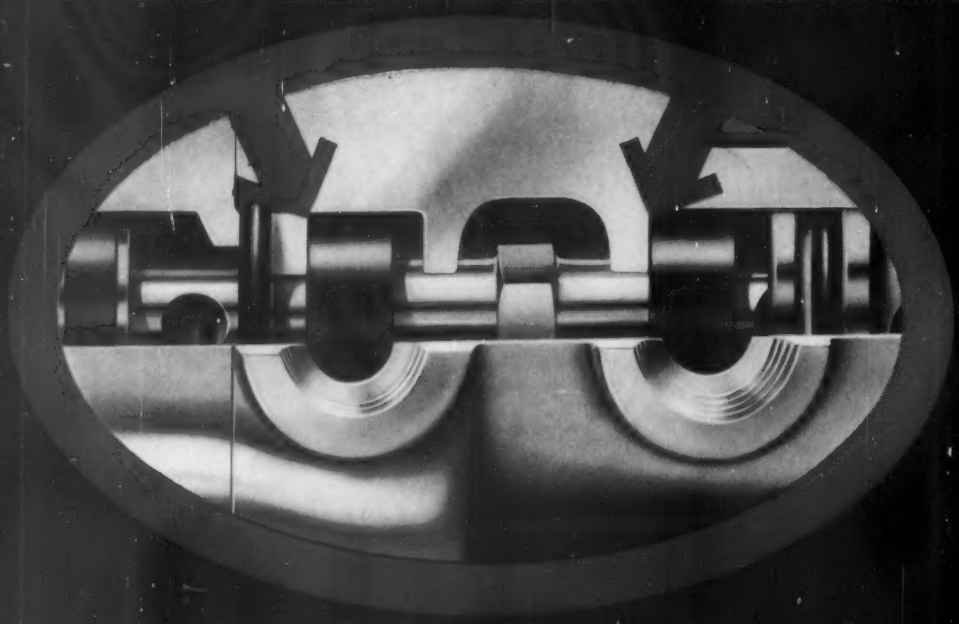

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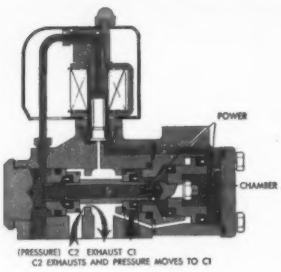
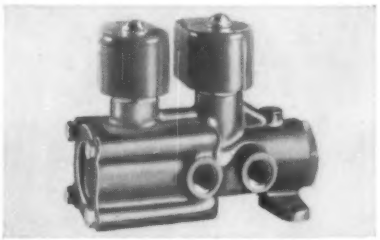
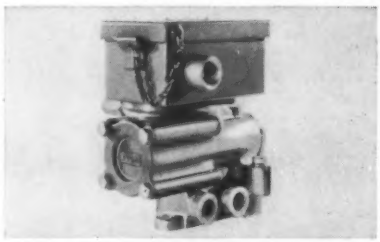


Operation: ASCO Single Solenoid 4-way Valves are power-driven in both directions by line pressure. When the solenoid is de-energized, line pressure applied to the top of the piston core forces it off the seat, eliminating possible sticking due to residual magnetism. Line pressure is applied to Chamber A, moving the piston-disc assembly to the left. When the solenoid is energized, Chamber A is exhausted and line pressure drives the piston to the right. Single solenoid type (illustrated) operates when solenoid is energized; returns automatically when de-energized.



Dual Solenoid (Bulletin 8344): operates when either solenoid is energized; will not return until opposite solenoid is energized (single solenoid types return when de-energized). In dual solenoid valves, solenoids may be energized continuously or momentarily.



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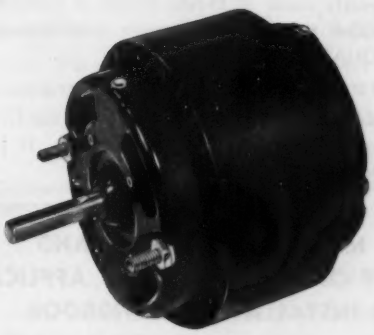

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Circle 404 on Page 19

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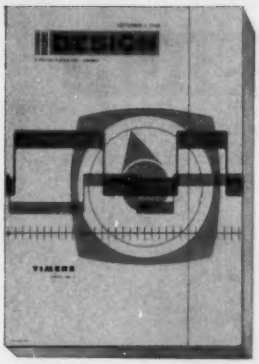

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EDITORIAL OFFICES
Penton Building, Cleveland 13, Ohio

Branch Offices
New York, Detroit, Chicago, Pittsburgh, Washington, London

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. When requesting changes of address, etc., please allow four to six weeks for processing.

Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

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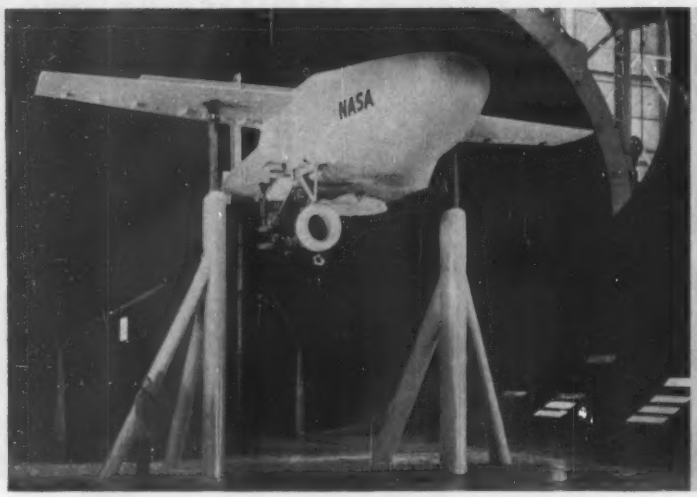
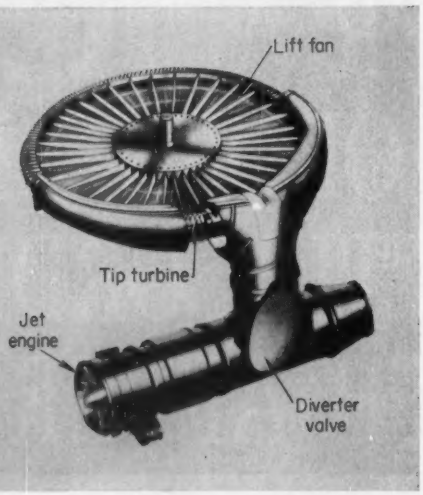
ENGINEERING NEWS

Lift-Fan Shows Promise for High-Subsonic VTOL





Three "building block" components—conventional jet engine, diverter valve, and fan—are incorporated in the lift-fan VTOL concept. In vertical flight, diverter valve deflects hot gas from the jet to the tip turbine. During transition from vertical to horizontal flight, the exit louvers, located at the bottom of the fan, direct fan exhaust rearward to provide horizontal thrust for forward acceleration. When the aircraft reaches sufficient speed for fixed-wing flight, the diverter valve is moved to the straight-through position, fan inlet and exit are closed, and the jet engine powers the aircraft normally.

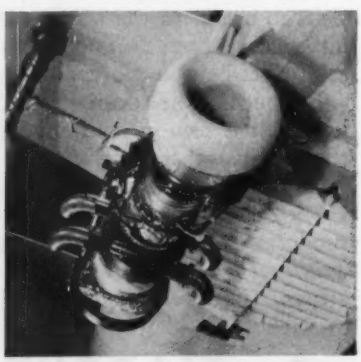
CINCINNATI — Despite a recent decision by the Defense Dept. to narrow the scope of research and development on VTOL vehicles, development continues on a number of promising craft under joint industry-military sponsorship.

One of the latest configurations to appear—an Army-General Electric Co. design effort—incorporates a lift-fan engine designed by GE. Full-scale tests in the 40 by 80-ft windtunnel at NASA's Ames Research Center have proved the feasibility of the craft.

Two of the lift-fan's big advantages are its light weight (1150 lb complete with engine) and near optimum ratio of takeoff to cruise thrust (about 3 to 1). Net result is a minimum dead-weight penalty (in the form of oversize engines, carried by many other VTOLs).

Fate of the lift fan, from a military standpoint, hinges around further windtunnel tests—and whether GE and the Army can prove its potential by getting a prototype in the air before a final VTOL design is adopted by the Defense Dept.

Tip-turbine driven, the lift-fan (left) has a top speed of 720 ft per second, delivers 10 lb of thrust per lb of fan weight. Sheet-metal scroll (right) extends partially around the fan circumference, feeds 1200-F gases from engine to turbine.



Louvered vanes, covering the fan-air exit, turn to the rear during transition flight in co-ordination with the diverter.

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Write for Technical Bulletin No. 59 on Eastman's new improved swivel connector.

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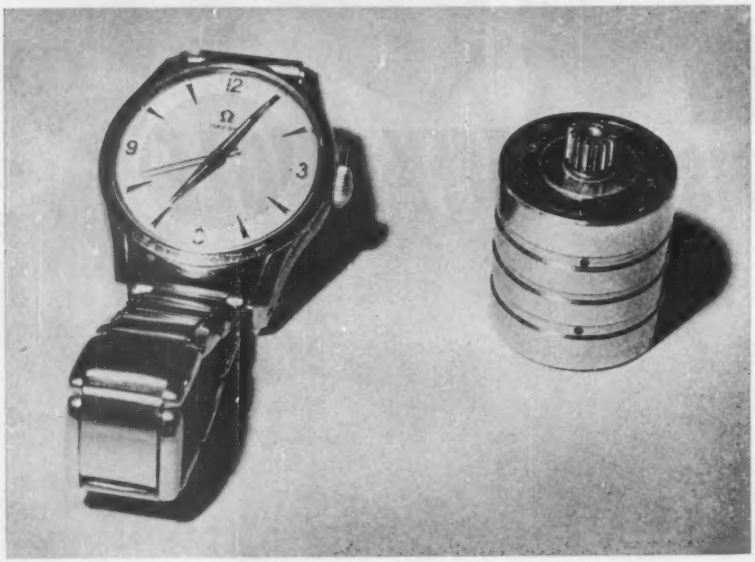
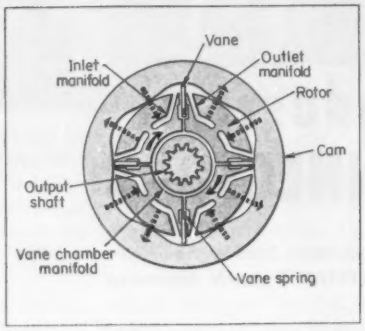
Hydraulic Motor Gives One Horsepower per Pound



Designed for aerospace, a compact hydraulic motor packs 1/3 hp in less than 1 cu in. It is 100 times smaller than an electric motor of the same power, says the developer, Bendix Corp., Southfield, Mich. It has a displacement of 0.02 cu in., maximum speed of 6000 rpm. Unusual port arrangements permit rapid reversal of rotational direction, and the motor maintains smooth, rather than pulsing motion, even at low speeds. Probable uses: Directional equipment such as servo-controls for space and marine vehicles.



First of the '61s

Bonded brake linings and an optional four-speed transmission with floor shift are major innovations in the '61 Studebaker Hawk. The "family-size sports car" retains last year's engine specifications: 289 cu in. displacement; 8.8 to 1 compression ratio; 210 hp at 4500 rpm. The engine burns regular-grade gasoline. Body dimensions also remain the same: Over-all length, 204 in.; wheelbase, 120.5 in. Hawks scheduled for California delivery are equipped with forced crankcase ventilation to reduce smog-producing exhaust. Gasoline fumes that escape through the cylinder rings are piped to the intake manifold for burning.

Topics

Tallow, an old stand-by in the candle and soap industries, has found a very modern application. It is being used as a base for jet-engine lubricants and is reportedly better able to handle extreme heat than lubricants having mineral bases. Last year 500,000 lb of tallow were used for this purpose; by 1975 the amount is expected to increase tenfold.

• • •

Ticker tape and magnetic tape will be used together to help fill a big statistical gap in data on the stock market. A study, sponsored initially by the University of Chicago Business School and Merrill, Lynch, Pierce, Fenner, & Smith, proposes to analyze the market, what makes it fluctuate, and what records indicate as a guide to investors. A Univac computer will record a variety of information on every common stock listed on the Big Board for the past 35 years.

• • •

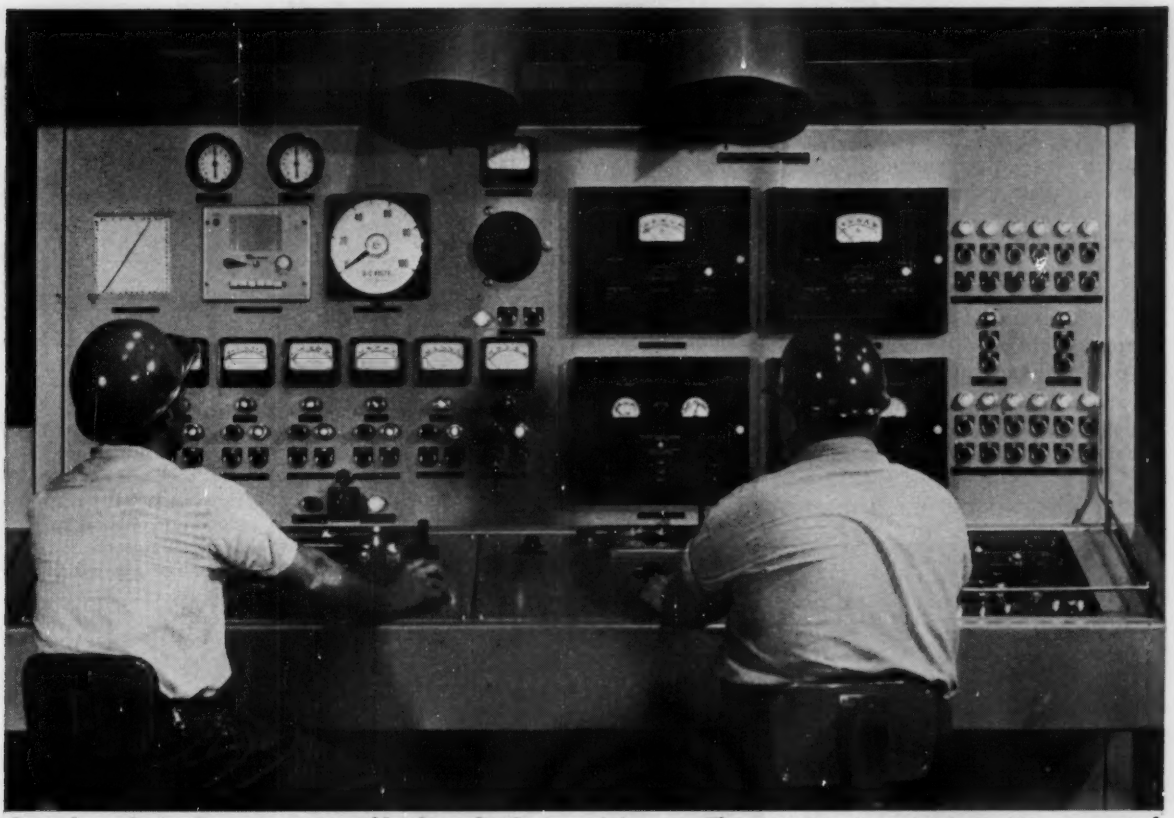
Putting the finger on the small glass area of a metal box is all that is necessary for making a fingerprint with a new optical system. Developed by Chance Vought Aircraft, PROOF —Precision Recording (Optical) of Fingerprints—provides exceedingly clear prints for direct observation or for permanent recording. Absence of ink eliminates smudging or distortion. The system is suggested for use with credit cards carrying an identifying print, and for police use in checking prints quickly enough to apprehend the so-called "hit-skip" forger.

• • •

Learn by doing-it-yourself kits include an explanation of engineering principles and theory along with instructions for assembly. Seven different kits have the makings of a multi-purpose test meter, two amplifiers and two speaker units, AM tuner, FM tuner, a dual-head tape deck, a telemetering system, and an output for punched cards and magnetic tape plus logical circuitry for a small digital computer. Strato Engineering Co., Burbank, Calif., markets the kits; prices range from $25.50 to $59.50.

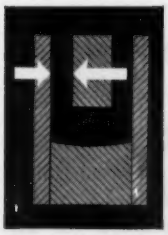
• • •

Mighty midget—a 3-lb jet-thrust indicator—can tell by listening to a jet engine when there is enough thrust for take-off. This job now requires 20 panel instruments and slide-rule computations. The indicator, developed by New York inventor Jerome Murray, precisely measures sound and frequency from a jet engine and shows these measurements in pounds of thrust on a simple dial.



Control panel of a Carpenter consumable electrode (Consumet) furnace. Electronic circuits maintain positive arc control and precise electrode movement to assure the ultimate in refining.

Where *Carpenter's* "big inch" makes a mile of difference in alloy quality



The "big inch" in Carpenter's consumable electrode (Consumet®) furnace is the extra space between the consumable electrode and the mold wall. (Conventional furnaces of this type are almost ⅓ smaller at this vital point.) The "big inch" in Carpenter's furnace provides more exhaust space to carry off harmful gases. It also gives Carpenter technicians more precise vacuum control during the arc strike as well as during the entire melting process. As a result, you get cleaner, more uniform alloys from core to surface. Segregation and variation in grain size are minimized . . . to assure you consistent, predictable performance from your vacuum melted alloys. The "big inch" is only one of many exclusive Carpenter quality controls in consumable electrode, MEL-TROL® and vacuum-induction-melted (VacuMeltrol®) specialty steels. Ask your Carpenter representative for the full story behind these alloys and how they benefit you.

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Circle 408 on Page 19

Computer Tests Man Of Man-Machine Team

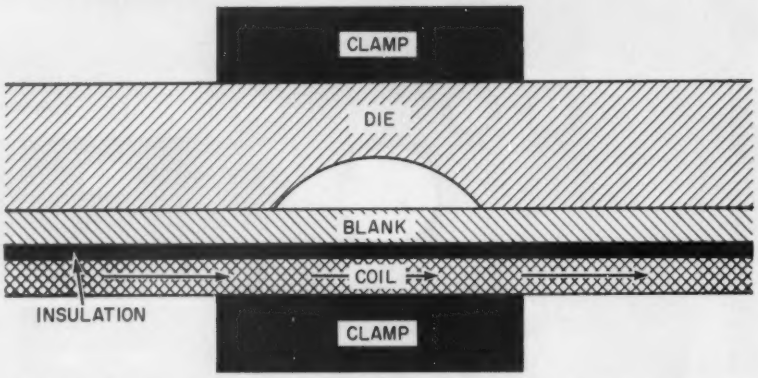
COLUMBUS, OHIO—New studies at Battelle Memorial Institute are pointing out the effects of automation on the human half of man-machine teams. A "problem-making" analog computer feeds a control board, and the board, with its array of lights and buttons, simulates the kind of equipment which requires constant human attention.

Subjects of the experiments watch a delicately balanced dial needle. When the control system is fully automated, no decisions are required; however, with the flash of

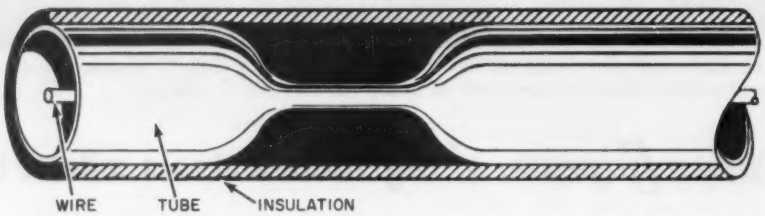
a light, the subject must take over control. During these manual-control periods, he determines whether the needle is properly aligned; if it is not, he indicates, by pressing a button, whether it is high or low, then pushes one of eight buttons to align the needle. Finally, the subject signals whether he was successful, by pressing either a button labeled "effective" or one labeled "not effective."

The control board, in effect, demands that the operator remain constantly alert to answer three questions: 1. Is the system operating as it should be? 2. If it isn't, what correction should be made? 3. Was action taken effective in correcting the system? These questions, basic to automation problems, will have to be answered no matter how sophisticated machines become. In fact, it is becoming increasingly important to designers to know how well, how quickly, and how often man can be relied upon to furnish the proper answers, Battelle psychologists report.

Intense Magnetism Heats and Shapes



Heat-treating, forming and even cutting will be performed more easily and less expensively by a method being developed by several aircraft companies. Electromagnetic forming will be able to handle most metals, and the better conductor the metal is, the more easily it forms; no residual magnetism remains in the workpiece. The magnetic force handles the metal in much the same way a rapidly expanding gas does (explosive forming), with one major advantage—it can be used indoors. Over 50,000 psi can be generated in 1/1000 sec, the time it takes for the condensers to discharge. Schematic drawing (above) illustrates simplicity of the system. Chief problems still to be solved are switching circuits for the very high electric currents involved, and construction of coils massive enough to withstand the forces. Dramatic example of electromagnetic forming (below) is the coaxial cable, whose insulation was not affected by forces powerful enough to neck down the wire.

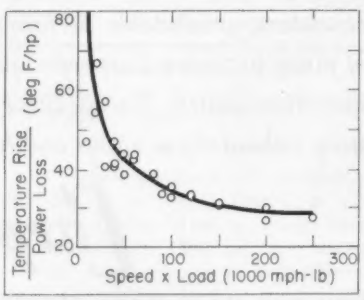


NBS Tackles Sticky Problem: Rubber Tire Rolling Friction

WASHINGTON — Few systematic studies have been undertaken to fix the rolling friction power loss of pneumatic tires. Yet this loss accounts for virtually all the power expended by highway vehicles. Contemplated changes in tire design, including the use of new materials, prompted a recent study by the National Bureau of Standards.

The study revealed that passenger car tires have greater power losses than those of trucks, and that natural rubber tires are more efficient than synthetics. Carbon black vulcanizing material has no effect on efficiency, according to the study, but steel and nylon cord show some advantages over rayon.

The experiments measured power losses in truck-sized and passenger-car tires simultaneously. Two dynamometers measured the power output at the tires, a third measured the power input. Accuracy of 0.1 per cent was maintained for all readings.



Typical results obtained from rolling-friction tests show the significance of rise in air temperature in a truck tire in relation to the tire's hauling ability (in terms of the truck's load and speed).

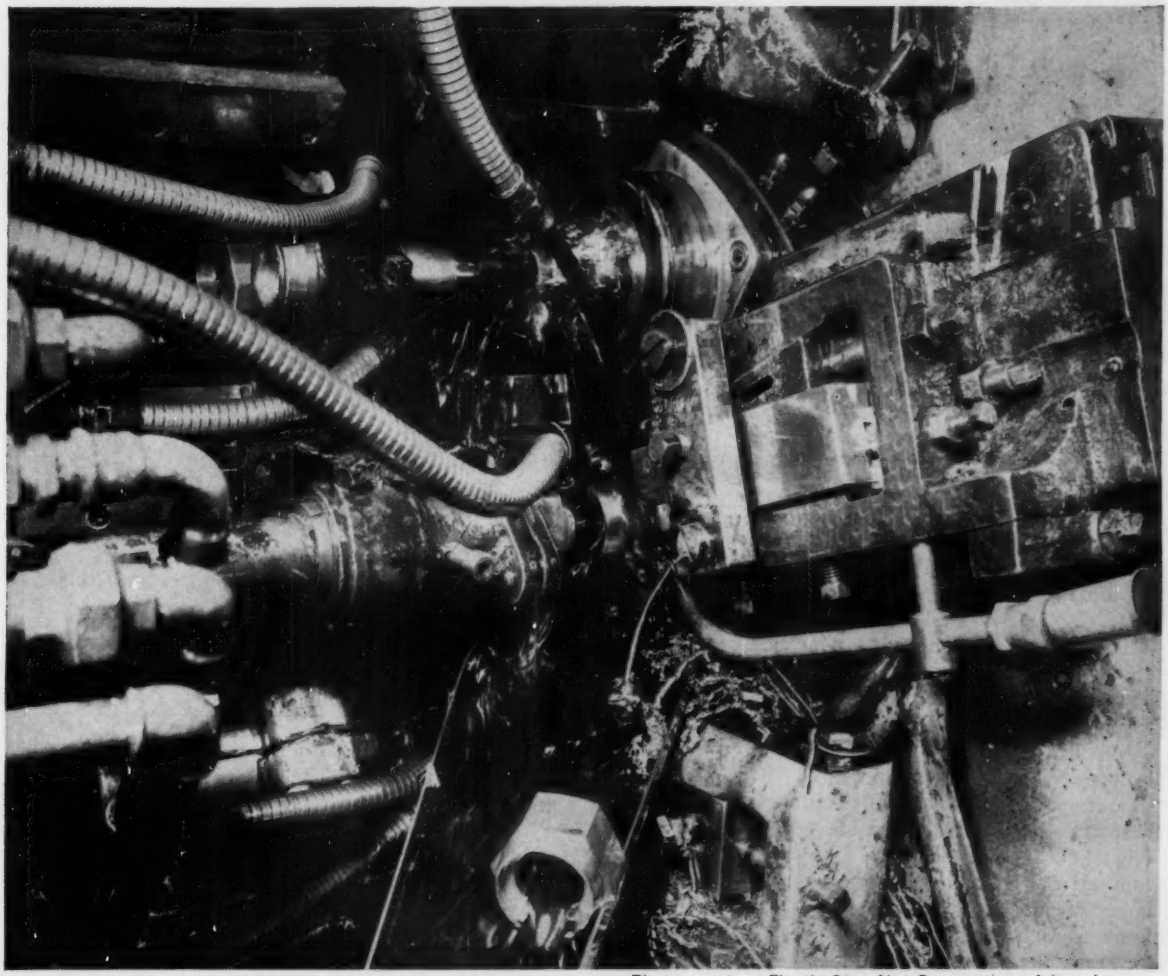


Photo courtesy Elastic Stop Nut Corporation of America

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Steel for self-locking hex nuts must be uniform in structure, easy to machine and free from internal and external defects. Elastic Stop Nut Corporation of America insists on these qualities . . . and gets them with Aristoloy cold finished bars.

Aristoloy Electric Furnace Steels, carefully controlled from melt shop to finishing operations, meet specifications for this and other applications requiring steel of uniform quality.

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Circle 409 on Page 19

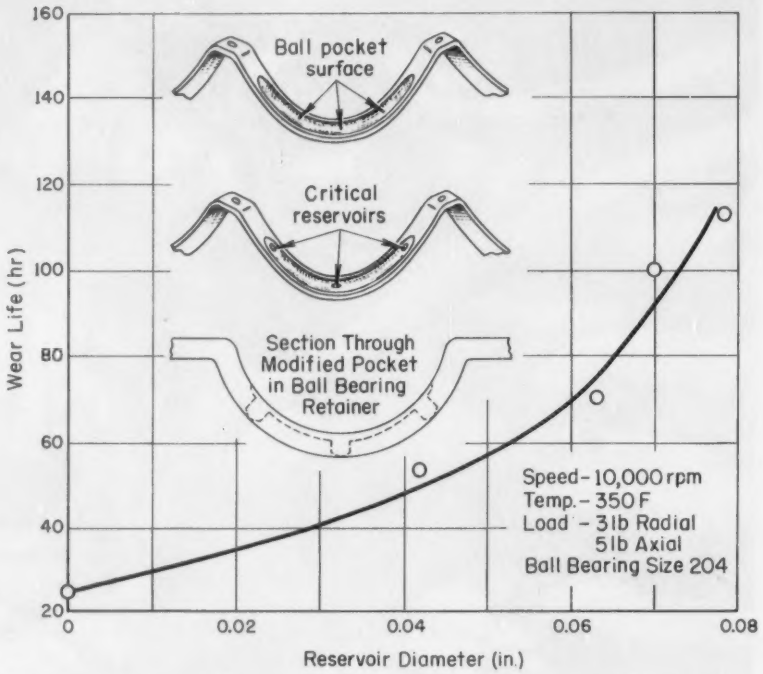
Reservoirs Key to Solid-Lube Success

PHILADELPHIA — Tests at Navy's Aeronautical Materials Laboratory show that the ball-retainer in a solid-lubricated bearing is as important to wear-life as the race, or the ball itself.

Earlier research at NAML, aimed at uncovering significant factors in inorganic solid-film lubrication, had confirmed that one major consideration is the substrate treatment (MD, June 23, pp. 30-31).

Study of the latest results, however, has uncovered an effect of unsuspected importance: Groups of "microreservoirs," continuously maintaining the lubricant supply, can significantly increase the bearing life. Further testing, by the Lab's M. J. Devine, E. R. Lamson, and J. H. Bowen, established that wear life hinges largely on the size, shape, number, and location of these reservoirs.

Modification of a retainer 0.15 in. wide by 0.035 in. thick produced cone-shaped depressions 0.015 in. deep and up to 0.025 in. in diameter (right). Using a typical lube (mixture of molybdenum disulfide, sodium silicate, and graphite), performance life of the bearing was increased 400 per cent, according to the Laboratory's reports.

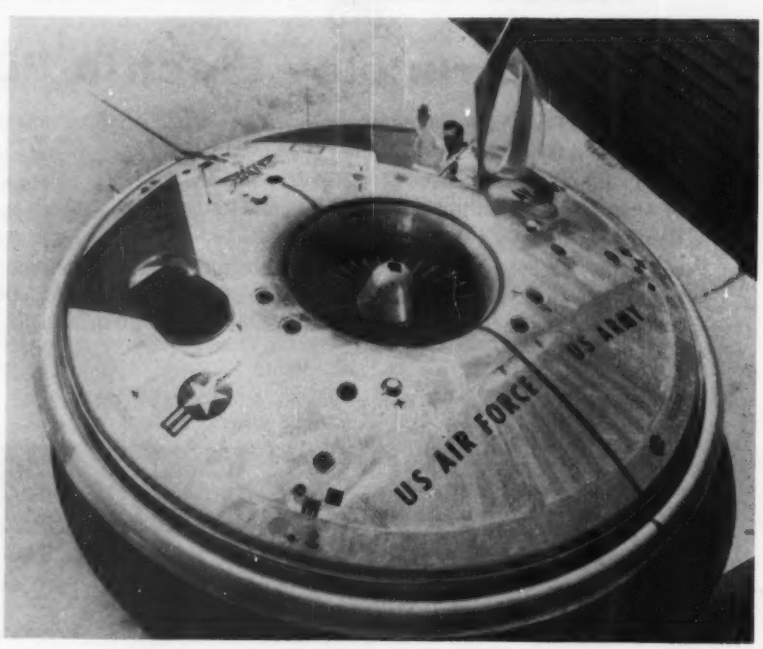


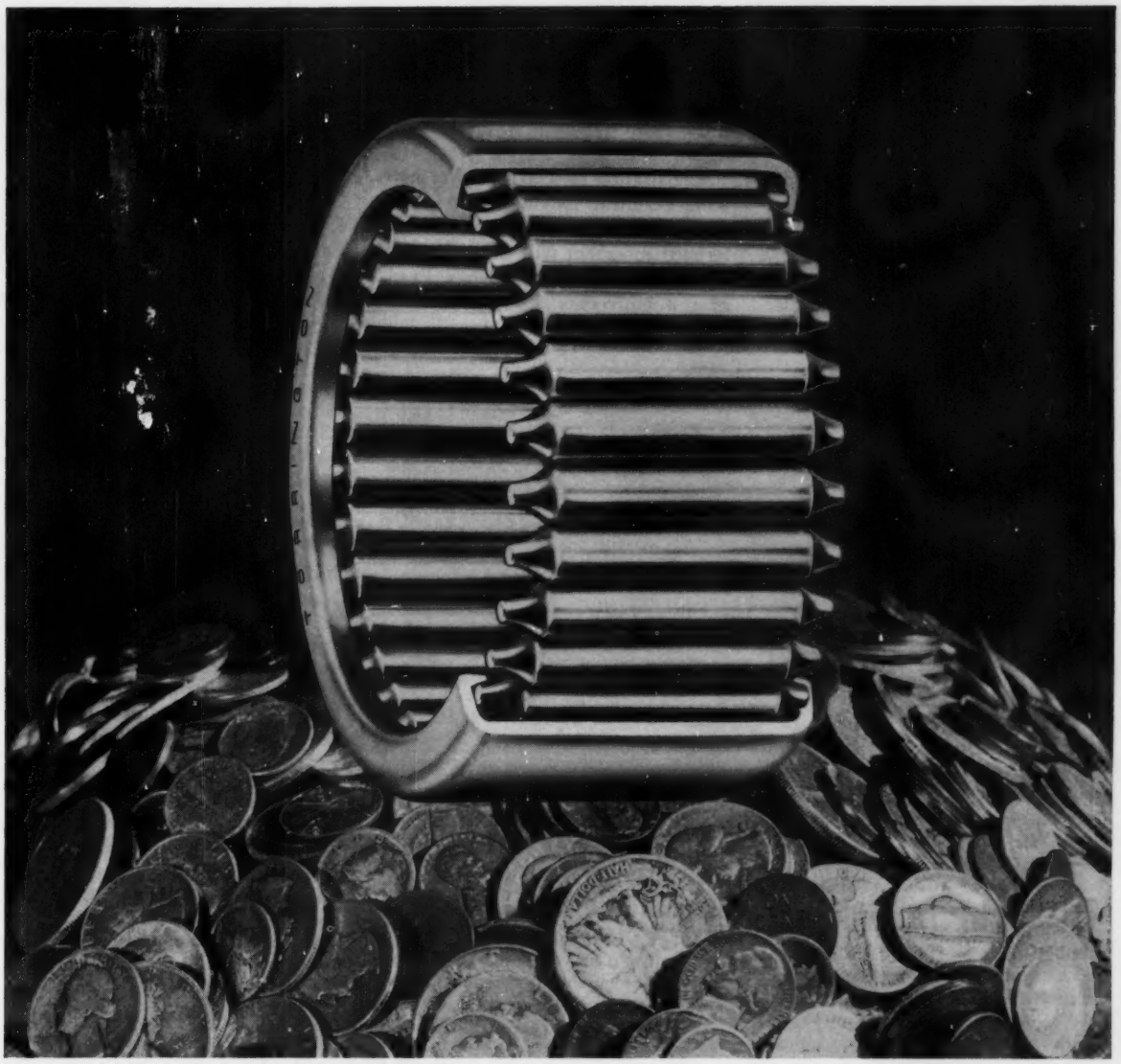
Tiny reservoirs, punched in retainer ball-pockets, considerably increase the life of a conventional ball-bearing. Graph shows that the effectiveness of the reservoirs is closely related to their diameters.

Particle size of solid lubes was also found to have an effect on wear life. In the case of MoS_2, an average particle size of less than 1 micron proved to be more efficient as a lubricant than larger particles.

Saucer's Fate Hinges On Windtunnel Tests

Most efficient low-level aircraft for sonic and supersonic speeds is a wingless one according to recent studies by NASA and several aircraft companies. This circular craft, because of its low drag, is an ideal platform, although relatively inefficient below 500 mph. Built for the U. S. Army and Air Force by Avro Aircraft Ltd., Canada, it is designed for ground effect and low-level flight. It achieves vertical take-off to a height of one wing diameter from the ground, then flies like a winged plane. Air, pumped from a central fan, is discharged downward from the rim of the wing, and a large volume of relatively low-speed air is drawn into the flow-path by a peripheral jet-pump effect. Performance of the craft has not been completely satisfactory (stability is the big problem), but the military will continue to support the program, pending further windtunnel tests.





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Circle 410 on Page 19

Outstanding Program Set for Sixth Mechanisms Conference

LAFAYETTE, IND. — Design and application of mechanisms will be the theme of an impressive two-day meeting, Oct. 10 and 11, on the Campus of Purdue University, Lafayette, Ind. The Sixth Mechanisms Conference, co-sponsored by Purdue's School of Mechanical Engineering and MACHINE DESIGN, will feature 17 papers presented by leading authorities in the field of mechanism design. Attendance is open.

Registration is scheduled for 8:30 a.m. (Central Daylight Time) in Purdue's Memorial Center. Conference members will be welcomed at 9:30 by Prof. Paul Chenea, head of the University's School of Mechanical Engineering.

Advance registration and room reservations for the Conference may be made by using the form which appears on page 183 of this issue. For additional information, write to K. E. Glancy, Division of Adult Education, Purdue University, Lafayette, Ind.

Program for the technical sessions is detailed below.

Monday, October 10

Registration: 8:30 a.m.
East Foyer, Memorial Center

9:30 a.m.—SESSION 1
Fowler Hall, Memorial Center
Chairman: Prof. G. W. Bergren, Purdue University

Welcome and Orientation
Dr. Paul Chenea, Head, School of Mechanical Engineering, Purdue University

Four Cornerstones of Kinematic Design
. . . principles that aid the cut-and-try process of mechanisms design and by-pass the mathematics of kinematic synthesis. *Thomas P. Goodman, kinematics engineer, General Engineering Lab., General Electric Co., Schenectady.*

Mechanics is Not a Closed Book
. . . a look at a long-neglected subject, elastokinesis — elastic-body mechanics. *C. W. Musser, research adviser, United Shoe Machinery Corp., Boston, Mass.*

1:30 p.m.—SESSION 2A
Room 214, Memorial Center
Chairman: Prof. R. S. Hartenberg, Northwestern University

An Application of Polydyne Cam Design
. . . how a seventh-order polynomial equation was adapted to a mechanical adder to compensate for dynamic effects between input and output. *S. A. Okcuoglu, advisory engineer, Engineering Laboratory, International Business Machines Corp., Lexington, Ky.*

Filter Theory Applied to Cam Dynamics
. . . a method for providing a suitable relationship between a definite input function and an indefinite output function. *Theodore Weber Jr., consulting engineer, Nyack, N. Y., and chief engineer, Cam Engineering Div., Howard Holmes Inc., White Plains, N. Y.*

Designing Cams for Analog Computers
. . . a method based upon charts by which the parameters for computing cams can be selected. *Charles Eumurian, principal engineer, Mechanical Div., General Mills Inc., Minneapolis, Minn.*

1:30 p.m.—SESSION 2B
Fowler Hall
Chairman: Prof. F. J. Bogardus, Purdue University

Series Design of Four-Bar Mechanisms
. . . procedure for designing two four-bars to generate a desired function with less error than possible with only one four-bar linkage. *Edward E. Hahn, Purdue University.*

Linkages with Rotating Input and Large Oscillating Output
. . . survey and analysis of various types of rotary-input mechanisms that will give an output oscillation close to and greater than 180 degrees. *Raphael Aronson, Purdue University.*

Synthesis of Four-Bar Function Generators
. . . mechanizing functions by using trace-derivation data. *J. P. Vidosic, professor of mechanical engineering, and H. L. Johnson, research engineer, Georgia Institute of Technology, Atlanta, Ga.*

Four-Bar Straight-Line Mechanisms
. . . analytical methods for designing mechanisms giving high accuracy over a limited range of motion. *Delbert Tesar, Department of Applied Mechanics, Kansas State University, Manhattan, Kans., and James C. Wolford, Department of Engineering Mechanics, University of Nebraska, Lincoln, Nebr.*

6:30 p.m.—BANQUET
Ballroom, Memorial Union Building
Toastmaster: Colin Carmichael, editor, MACHINE DESIGN

Tuesday, October 11

8:30 a.m.—SESSION 3A
Fowler Hall
Chairman: Prof. F. R. E. Crossley, Purdue University

Statics and Dynamics in 3-D Mechanisms
. . . a survey of techniques—analytical and graphical—for finding forces and moments in spatial mechanisms. *Rudolf A. Beyer, visiting professor, Mechanical Engineering, Yale University, New Haven, Conn.*

Space-Linkage Layouts on a Computer
. . . large savings in time and expense plus advantages of accuracy, ease of handling complex problems, and automatic generation of mathematical expressions for loci can be effected by digital computers. *D. W. Zawada, systems research department, Ford Motor Co., Dearborn, Mich.*

Synthesis of Plane Mechanisms
. . . an appraisal of a recent Russian volume by Artobolevski, Levitskii, and Cherkudinov. *Douglass P. Adams, associate professor of mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass., and Alexander Samoiloff, engineer, E. B. Badger Co., Cambridge, Mass.*

8:30 a.m.—SESSION 3B
Room 214, Memorial Center
Chairman: Jesse W. Huckert, associate editor, MACHINE DESIGN

The Cardan Positions of a Plane
. . . resolution of an apparent divergence in two well-known definitions of the "instantaneous Cardan positions." *Ferdinand Freudenstein, associate professor and chairman, Department of Mechanical Engineering, Columbia University, N. Y.*

Inverted Slider-Crank Mechanism

. . . analytical expression, adaptable to computer programming, for displacement characteristics and a simplification suitable for a desk calculator. *George A. Bucci, design engineer, Servo and Mechanics Dept., Raytheon Co., Wayland, Mass.*

Six-Bar Linkages

. . . a digital computer method for analyzing large numbers of similar linkages to find optimum configurations. *A. C. Dunk, associate professor of mechanical engineering, Purdue University, Lafayette, Ind., and C. L. Hanson, mechanical engineer, Lawrence Radiation Lab., University of California, Livermore, Calif.*

12:15 p.m.—LUNCHEON
Faculty Lounge, Memorial Union Building
Toastmaster: Prof. E. S. Ault, Purdue University

Engineering Education in the Netherlands

. . . *W. L. H. Schmid, dean of mechanical engineering, Technological University of Eindhoven, Eindhoven, Netherlands.*

1:45 p.m.—SESSION 4
Fowler Hall, Memorial Center
Chairman: Ben Hummel, associate managing editor, MACHINE DESIGN

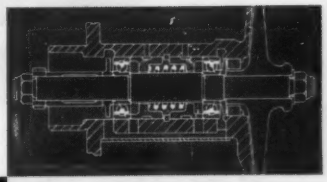
Prosthetic Mechanisms for Leg Amputees

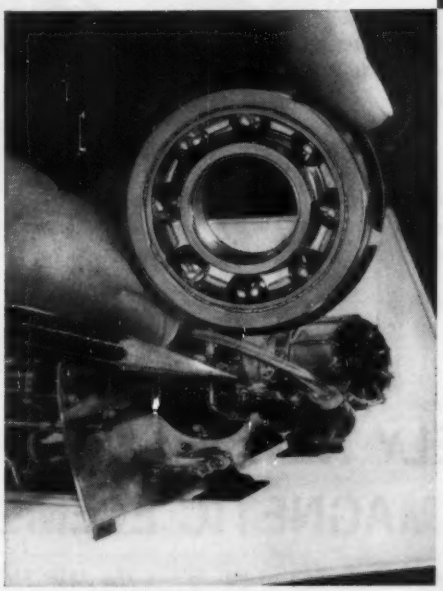
. . . describes some of the engineering problems in development of modern prosthetic components to replace functional losses resulting from leg amputation. *Prof. C. W. Radcliffe, University of California, Berkeley, Calif.*

General Discussion

. . . an open-forum period headed by conference co-chairmen Hall and Hummel.

1,200,000 DN TURBINE BEARING OPERATES AT 600° F





Turbine shaft speeds up to 60,000 rpm and 900° F exhaust gases were the severe service conditions ITI engineers had to consider in designing turbine bearings for the Sunstrand Model 871 flight vehicle power unit. By custom-engineering tool steel ball bearings with strong, lightweight separators, and then pre-loading them in a reversible thrust-type mounting, ITI was able to increase useful operating life from 2 to 75 hours. Complete technical data on this unusual high temperature bearing is available in Tech-Tonic #3, or for information on how ITI can design and produce in quantity other special bearings having corrosion resistance, extreme precision, or unusual configuration, write for Bulletin AFB-2.

INDUSTRIAL TECTONICS, INC.
manufacturers of precision balls and bearings
BEARING DIVISION | 18301 SANTA FE AVENUE, COMPTON 1, CALIFORNIA

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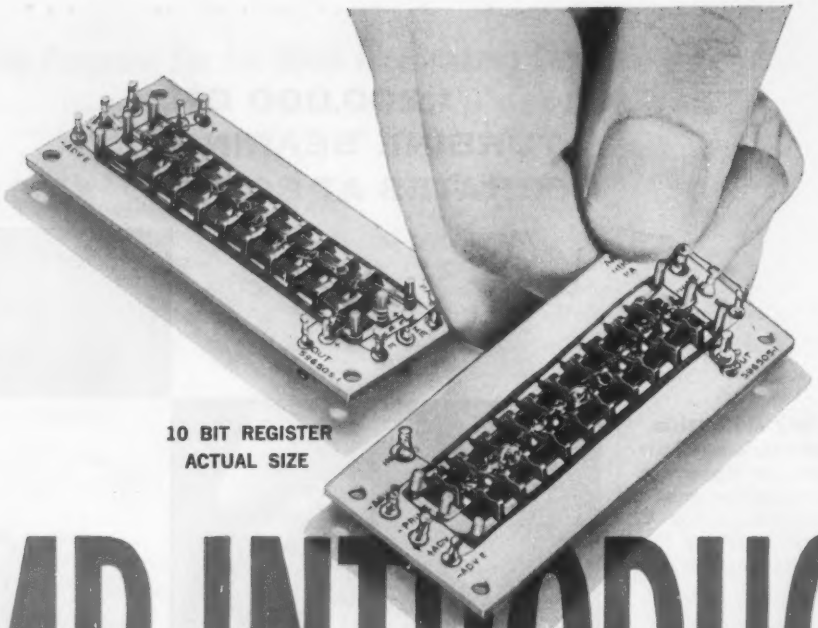

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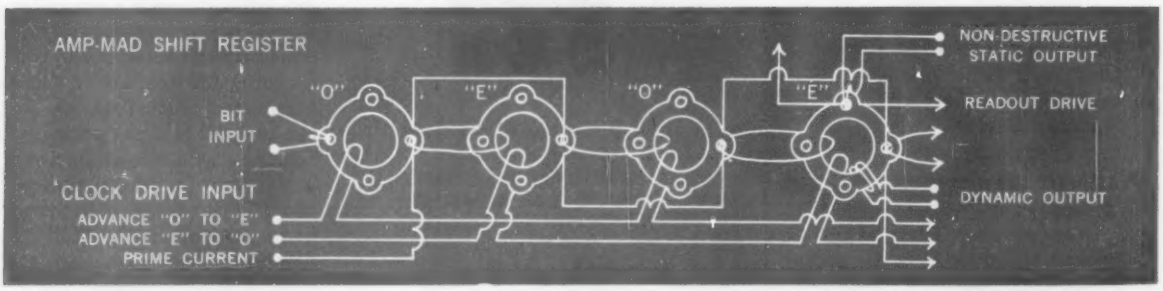

For complete information, including operating data, send for our AMP-MAD Shift Register brochure.*

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CIRCLE ITEM NUMBERS—Throughout the magazine, each advertisement carries an Item Number for use in requesting further information. All product descriptions, announcements and Helpful Literature items are also numbered, and for greater convenience are indexed below by Item Numbers.

EDITORIAL CLIPSHEETS—So you won't have to "clip" this issue, we'll be glad to send a personal copy of any article as long as the supply lasts. Just fill in the page number and title of article in the place provided on the Yellow Card.

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Sept. 1, 1960

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413	443	473	503	533	563	593	623	653	683	713	743	773	803	833	863
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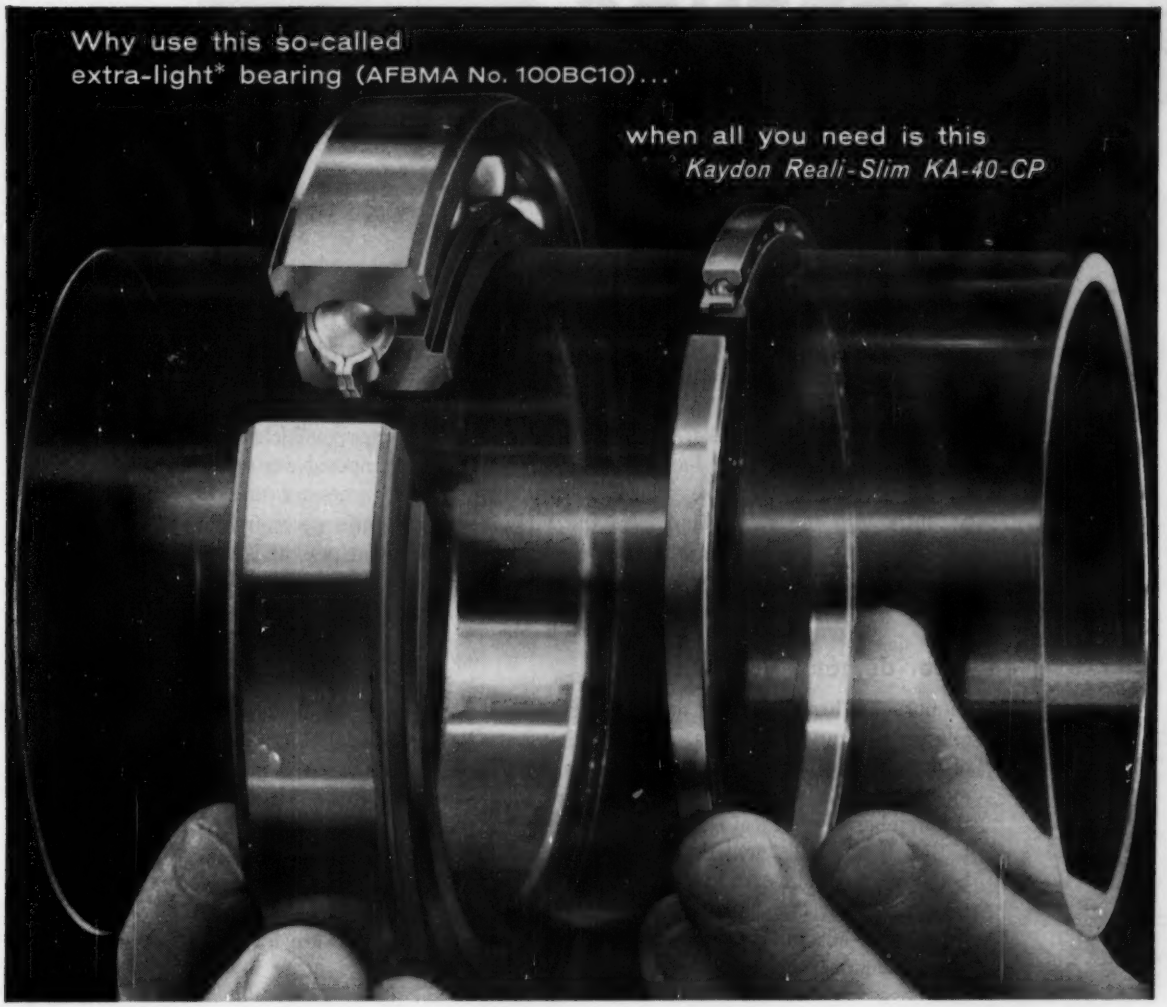
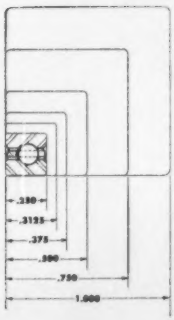


News from Kaydon!

Reali-Slim bearings "off the shelf" ...prices slashed up to 76%



*Five of the six series of Type "CP" Reali-Slim bearings are smaller in cross section than the AFBMA standard "extra-light" series bearing shown above.

Up to 85% lighter, up to 70% narrower than the lightest of the "extra-lights"

More than 80% of all present standard "extra-light" series bearing installations never require the full capacity of the bearing.

Kaydon now trims this expensive bearing excess! Kaydon Type "CP" Reali-Slim bearings match proper size, weight and capacity to specified shaft sizes. Overcapacity need no longer hamstring your product designs.

Here's why! In Kaydon's new Type "CP" Reali-Slim bearings (world's thinnest), width and cross section *remain the same* for all bearing sizes in any one series.

Example: each of the 15 sizes from 4" to 12" bore in the Reali-Slim KA series has only ¼" width and cross section. Result: new opportunity to save on cost, size, and weight . . . in bearings and adjacent components.

Availability? Now off-the-shelf in 90 sizes with Conrad deep-groove, ball-radial construction . . . and new bronze one-piece snap-over separator in 4" to 12" bore — ¼" to 1" width and cross section. Kaydon's volume production cuts prices as much as 76%, depending on size. Write for free, fact-filled "CP" bearing bulletin — with prices!

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All types of ball and roller bearings — 4" inside diameter to 178" outside diameter . . . Taper Roller Roller Thrust • Roller Radial • Needle Roller • Ball Radial • Ball Thrust • Four-Point Contact Bearings

K-160

Circle 413 on Page 19

ground effect in space

While most research on disc-shaped "aircraft" is concentrated on VTOL capability, the Air Force has quietly been studying this configuration for orbital and re-entry vehicles. For space work, the disc claims several inherent advantages: It would make a lightweight, strong, and compact vehicle, with plenty of area exposed to handle the high heating loads imposed during re-entry. It would also have the good drag characteristics necessary to slow its entry into the atmosphere, plus the high lift-to-drag ratio necessary for maneuverability within the atmosphere. Biggest drawback at present is controlability, but this problem is also shared by most other configurations.

engineer-demand yardstick

Rumor and hearsay about demand for engineers may soon be replaced by relatively accurate forecasts. *Engineer/Scientist Demand Index*, a new series of monthly reports from Deutsch & Shea, New York, will be based on recruitment counts in representative newspapers and technical journals. Although the number of technical employees sought during each preceding month won't be listed, the Index will provide, for the first time, a continuing measure of both number and lines of recruitment advertising. This information relates to the extent and intensity of the recruiting effort, D&S spokesmen claim, and the lines-to-ads ratio will tip off how much money companies are investing in the engineer hunt.

vehicle propulsion: era of the common fuel

Increased use of automotive diesels and gas turbines anticipated during the next decade could trigger the development of a single grade of "wide-band" fuel, according to J. H. Pitchford, British diesel designer. He predicts that all classes of vehicles, with the exception of the "hard core of small private cars powered by spark-ignition engines," will burn the same petroleum mix. Although "formidable" problems would be involved, requiring exceptional co-operation between the auto and oil industries, the simplification promised in world-wide fuel transport, blending, and distribution would be of such magnitude as to make the program extremely desirable. Looking even further ahead, Mr. Pitchford thinks the common fuel might be suitable for aircraft gas turbines.

education: the rising cost of professionalism

Students at the University of Michigan who are working on undergraduate degrees may soon find themselves in the minority. According to U-M president Harlan Hatcher, graduate students make up almost 40 per cent of the University's current enrollment, and nearly all of these 10,000 members of the student population have their baccalaureate degrees. And as the demand for graduate-level training continues to accelerate, so does the cost involved—in some fields the cost of graduate study runs 14 times as much as a standard undergraduate course.

Army picks lunar real estate

Government geological experts have just completed terrain studies of the moon for use by the Army in establishing lunar bases. The year-long "photogeologic" study included construction of three giant charts of the moon, prepared with the aid of thousands of photographs. According to Army spokesmen, one of the best lunar landing sites is in the Copernicus-Keppler region (lower earthside), but more than 70 other regions have been marked out according to their desirability as landing, movement, and construction sites. One significant result of the study: It upsets earlier beliefs that the moon is covered with deep layers of dust. Biggest impediments to mobility now appear to be huge cracks and faults of the surface, and mountains 30,000 ft high.

ignition systems go to college

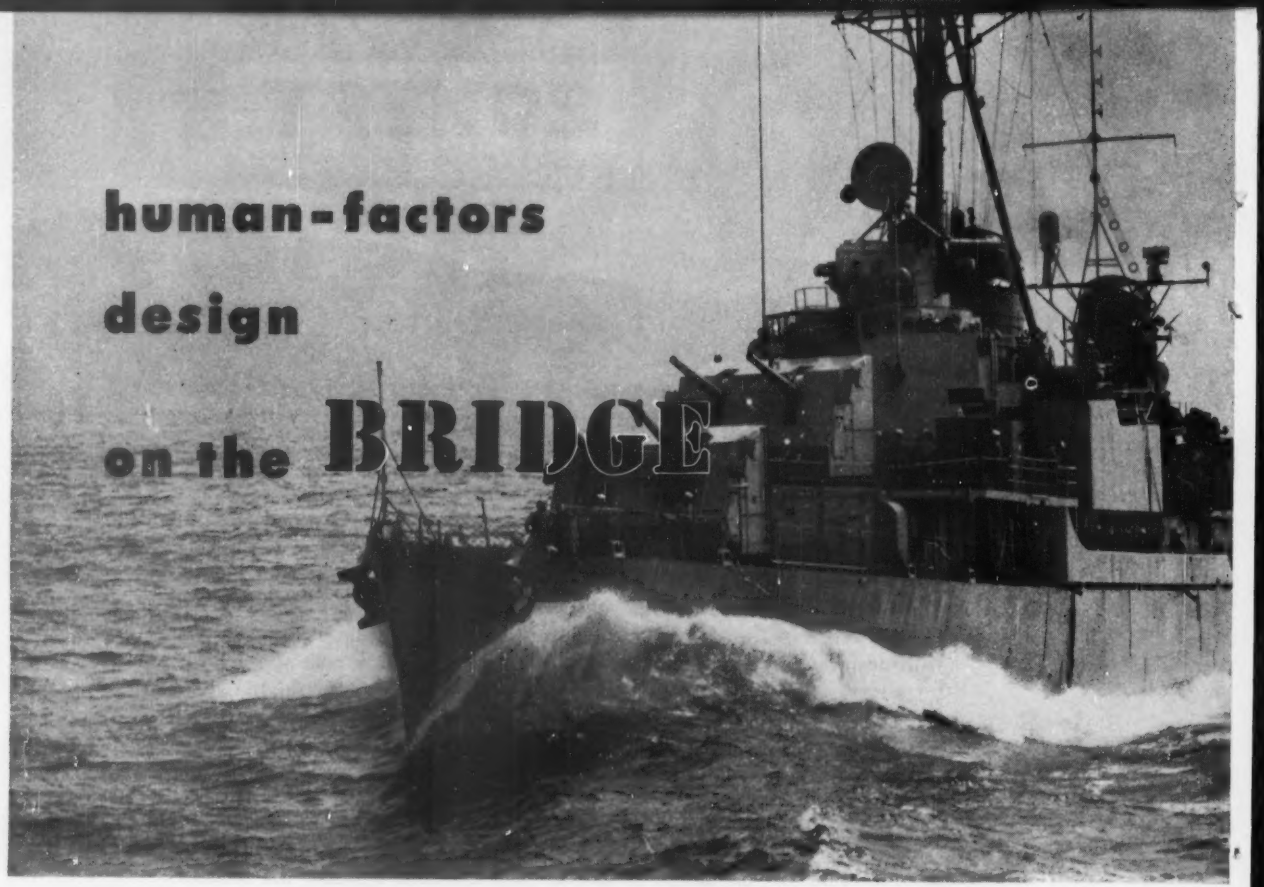
Traveling "teachers" from Electric Autolite Co. are now scheduling seminars for students at leading engineering schools. Devoted primarily to the impact of semiconductors on design of ignition and electrical systems, the seminars will present material well beyond the scope of current textbooks. Top engineers from Autolite's research and development divisions (the teachers) plan to discuss up-to-the-minute laboratory findings and other subjects that will aid the colleges in keeping up with this highly specialized but vital area of modern engine and equipment design.

U-2 with missile

Missileer, Navy's subsonic missile-carrying plane now on the drawing boards at Douglas Aircraft Corp., reverses the current trend toward aircraft sophistication. The plane will depend on the performance of its Mach-4 Eagle air-to-air missiles to accomplish intercept missions. Designed to fight efficiently at high (100,000 ft) or low altitude, the twin-engine launching platform will carry six nuclear-tipped Eagles and four crew members (two pilots, two radar operators). Its subsonic performance (including an 86-knot landing speed) will give the craft exceptional airborne endurance.

new attack on thermoelectrics

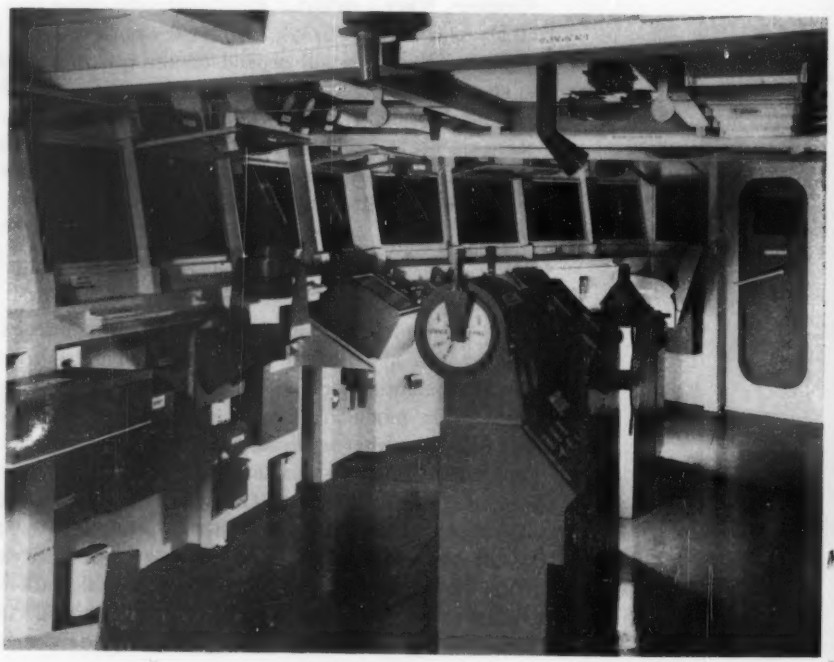
Many of the fragile, hard to fabricate semiconductors now under study might convert heat to electricity efficiently. But unless the thermoelectric properties of these materials are known in advance to be good, the expense and time involved in producing large, tough, crack-free specimens may not be worthwhile. To solve the problem, researchers at General Atomic Div., General Dynamics Corp., are working up ways of determining properties from minute, irregular-shaped samples. Thermoelectric voltage can be measured by passing a current through a tiny contact to a sample (contact voltage is a function of the heating current), and low-current resistance data can also be obtained. This information is all that's needed for calculation of thermoelectric power and thermal conductivity. According to General Atomic, the new approach provides a powerful tool for studying materials at high temperature.

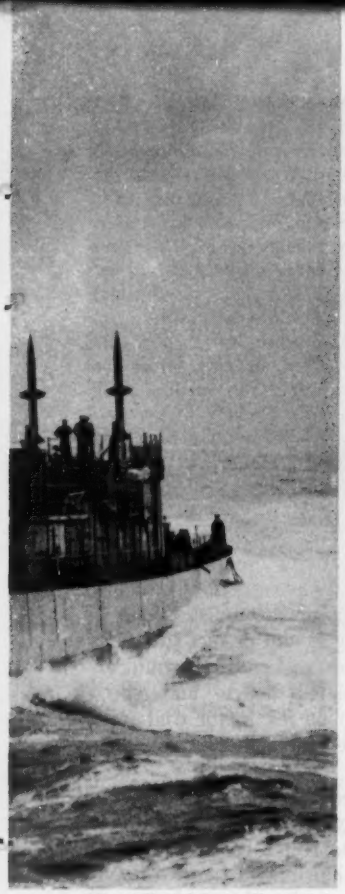


human-factors design on the BRIDGE

ROBERT O. DONOVAN
Head, Command Stations Section
U. S. Navy Bureau of Ships
Washington

The traditional picture of the ship's Captain—standing on an icy bridge, peering through the gloom—is fast disappearing. Today's heavy sea traffic, fast ships, and long-range weaponry, demand decisions that are quick and sure . . . made by men untrammeled with physical discomfort. In this article, Bureau of Ships' Chief of Command and Combat Stations Section shows how human-factors engineers are creating bridges that are the epitome of efficiency.





Official United States Navy photo

WHEN prehistoric man carved his first dugout—and got his mate to help paddle it—he created a design problem that engineers and naval architects are still working on: Command and control of a ship.

Like the early boatman, the captain of a modern ship wants a station where he can command his vessel and its crew, see where it's going, and know everything concerned with getting there. Designers are busy applying new materials, equipment, systems, and arrangements toward a solution.

Too many hands

The ship's bridge is the place of command and control. Usually divided into an enclosed pilot house (or wheelhouse) and an exposed open bridge, it has at best represented a design compromise. As ships have grown in size and complexity, as speeds and sea traffic have increased, and legal requirements have compounded, the demands for an efficient command station have grown acute.

Failure to meet them has multiplied the number of people needed to man a ship's bridge. Two or three are now the minimum for any commercial ship; a Navy combat ship, at general quarters, may take a dozen or two. Costs, of course, go up with the number of personnel, and the very complexity of co-ordinating the varied tasks has led to human errors that have ended in tragic sea disasters. Design effort today, which leans heavily on the principles of human-factors engineering, is moving steadily toward more automation on the bridge.

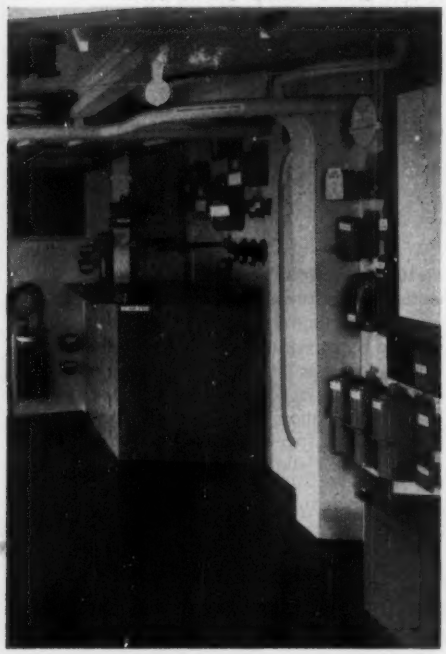
Alertness in comfort

New shapes and arrangement of bridges in both naval and commercial ships are emphasizing visibility and protection from the weather. Although the aim is to move all control functions inside, every design retains open bridge wings to some degree for functions such as docking or replenishment at sea, where maximum visibility from the extreme sides of the ship is a must.

New developments in glass permit design of large rectangular panels instead of the traditional round portholes. Tinting the glass and tilting the panels minimize glare and reflections, and laminated glass (up to 2 in. thick in some naval ships) has a transparent electrical heating layer for de-icing. Windshield wipers keep the panels clear of rain, snow, and salt spray.

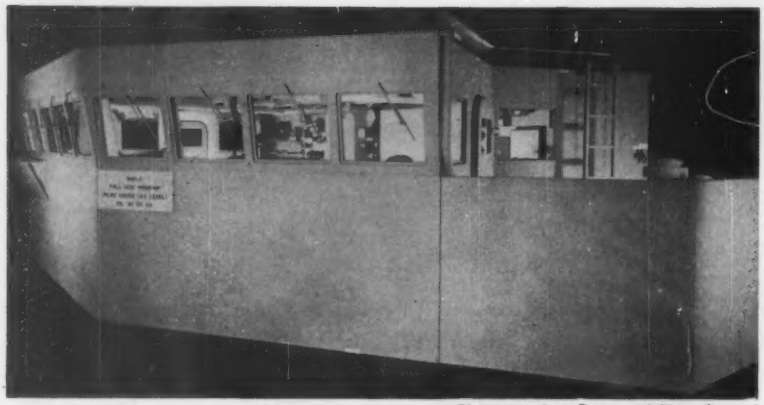
Many bridge windows are designed to open in good weather, but

Photo, courtesy Bureau of Ships Journal



Human-factors engineers consulted with Navy fleet officers in developing this full-scale mock-up of a DDG-2 pilothouse (destroyer, above). The combined pilothouse and bridge will be standard on all future Navy vessels. The mock-up illustrates key factors in design of command and control centers:

- Visibility . . . 360 degrees, if possible, from the waterline to the horizon, and hemispherically above the ship.
- Protection . . . for personnel, from weather, noise, nuclear fallout, and near-miss weapons effects.
- Display . . . of all factors, including maneuvers of nearby ships, status of machinery, cargo, weapons and personnel, plus all tactical information.
- Control . . . of ship's steering and propulsion, of weapons and vehicles, communications, and damage-control functions.
- Recording . . . facilities for entering and keeping data in ship's logs, and other necessary records.
- Personnel . . . fewest men and lowest level of skills that can adequately control the ship.
- Costs . . . that must be finely balanced for both naval and commercial designs. Many devices are priced out of consideration, if not essential.



Photo, courtesy Bureau of Ships Journal

Totally enclosed control station has yet to be achieved, but the Navy's Ship Characteristics Board has approved a radically new bridge that combines the two stations of pilot house and open bridge. Though modern radar has lessened the likelihood of initial detection being made visually at sea, important use is still made of efficient human perception at short ranges. Emphasis in the external design of a control station is on visibility—from the waterline to the horizon, ideally, in all directions—and protection of the personnel from weather, noise, and weapon-effects.

an exception is made on aircraft carriers where jet-aircraft noise often reaches an ear-splitting 135 db. Here, extensive soundproofing and about 10 tons of air-conditioning keep the bridge quiet and comfortable. Enclosed bridges are heated by radiant electrical panels or steam or electric convectors.

Some commercial designs have sliding doors between enclosed and open areas to avoid the dangers offered by heavy swinging doors on a rolling ship or in high winds. The Navy, reluctant to trust sliding doors where minor battle damage could jam them, protects the entrances by angling bulkheads inboard from a wide front so that the sides shelter the doorways.

Automation on the bridge

Even a simple conning situation involves many human decisions. They must be based upon trained analysis of factors both within the ship and external to it. The amount of data to be received, displayed, analyzed, and acted upon has grown to such proportions that ever-increasing installations of advanced display devices have not yet met the needs.

Radar has long aided the seaman's eye in piloting and collision avoidance, but the solution of purely relative motion problems—either visually or by radar—demands training and experience and is still prone to human errors. New "true-motion" scopes make the radar display an accurate geographic map. The ship and all nearby traffic move realistically across the scope as land masses or other fixed references remain stationary.

Improvements soon to come promise automatic alarms for radar contacts that might create a collision hazard. A further development may use a computer to track the most critical targets and predict situations several minutes hence. It would allow simulated course and speed changes to be fed in for trial solution before real maneuvers need be made.

Improved navigational systems promise greater accuracy in determining the ship's geographic position. Combined with better surveillance of nearby ships, the result should be a significant easing of the human decisions involved in conning.

Besides radar, at least a dozen indicators are required on the bridge. They give a range of information: Course-and-speed; temperatures in a hold or magazine; or reactor conditions on a nuclear ship. The list includes almost any factor which must

Electrical controls which are replacing cables and cranks in many instances, now permit some engine room functions to be carried out directly from the bridge. This engine-room telegraph is designed for a controllable-pitch-propeller installation. The console indicates ship's speed, propeller speed, pitch, and air supply.

Photo, courtesy Sperry Piedmont Co.

Master control for the steering system aboard a commercial vessel can be operated either manually (electrically assisted) or automatically. Five monitor controls, two for automatic steering and three for hand steering, are located at vantage points throughout the pilot house and bridge, allowing close-quarter docking and maneuvering. Information on the master console is displayed by a course-setting indicator, compass repeater, rudder order, and angle indicators.

be interpreted quickly and accurately. Most of these displays have to be repeatedly checked by conning officers scanning their analog scales to keep up with the status of everything aboard. Many readings have to be logged to comply with legal requirements.

Indicating systems with a common language digital readout are now being developed that keep their own logs by means of recording and printout devices. Digital displays will still be available to bridge personnel. These will require little attention during normal conditions, but will flash or sound an alarm when all is not well.

The action-taking functions—controlling course, speed, and other operating factors—are also being improved. One-man control of steering and propulsion is an important achievement for economic reasons, as well as for safety. The tremendous inertia of a ship makes its response to control far different from a land vehicle or aircraft. But

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Circle 414 on Page 19

"quickening" is being built into the control loops to achieve smooth maneuvering with less extensive training and experience of bridge personnel.

A completely integrated control system is under intensive study, wherein a computer is fed all navigational, status, and surveillance information. Suitably programed with data concerned with operating efficiency, destination, schedules, and other factors, it would directly control the ship's machinery and systems.

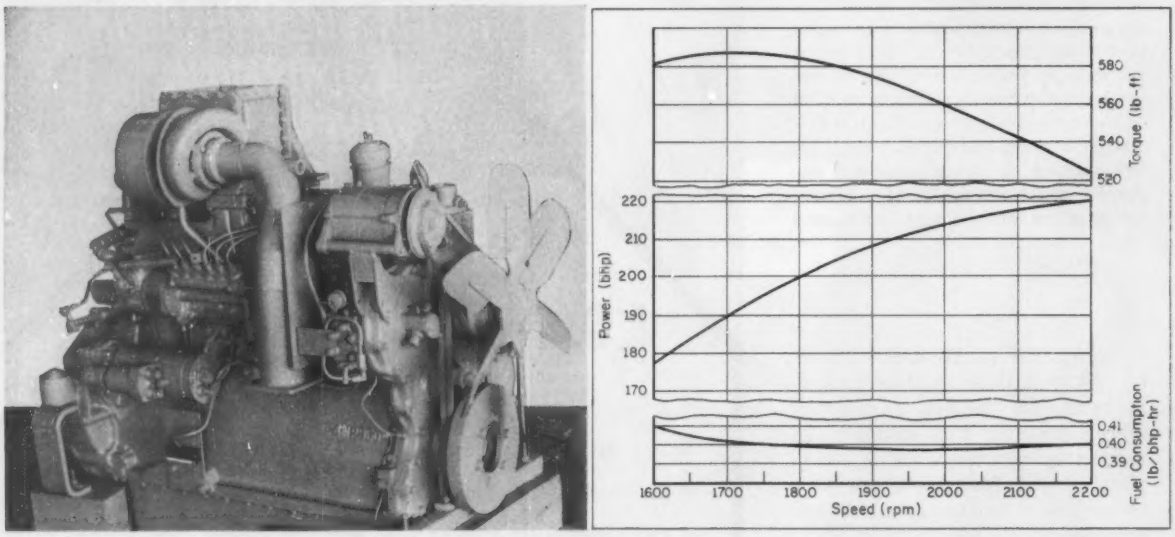
Human monitoring and occasional intervention would still be necessary, however. Some control actions defy complete automation. Nevertheless, automation of tasks that machines do as well as, or better than, a man will relieve him for service where his judgment is essential.

Communications speed-up

Communications have not been overlooked. Bridge-to-bridge radio is now common and some highly advanced systems are in prospect for handling the complex tactical needs of naval combat ships. Stored-standard-message transmission systems are being looked into, and automatic recording equipment may soon provide important evidence in collision incidents. One commercial proposal marries ships' radar and radio facilities. A captain on one ship can point to a target on his radar scope electronically and automatically identify and establish communications with the second ship representing that radar blip. Improved optical systems will use infrared transmission for short-range talk.

Aboard ship, co-ordinating operations and damage control requires a variety of interior communications techniques, ranging from the old-reliable sound-powered phones to closed-circuit television. Television gives the bridge a view of missile launchings or nuclear power-plant operations remotely; it also augments verbal briefings on tactical situations plotted below decks.

Earthmoving Diesel Hits the Road



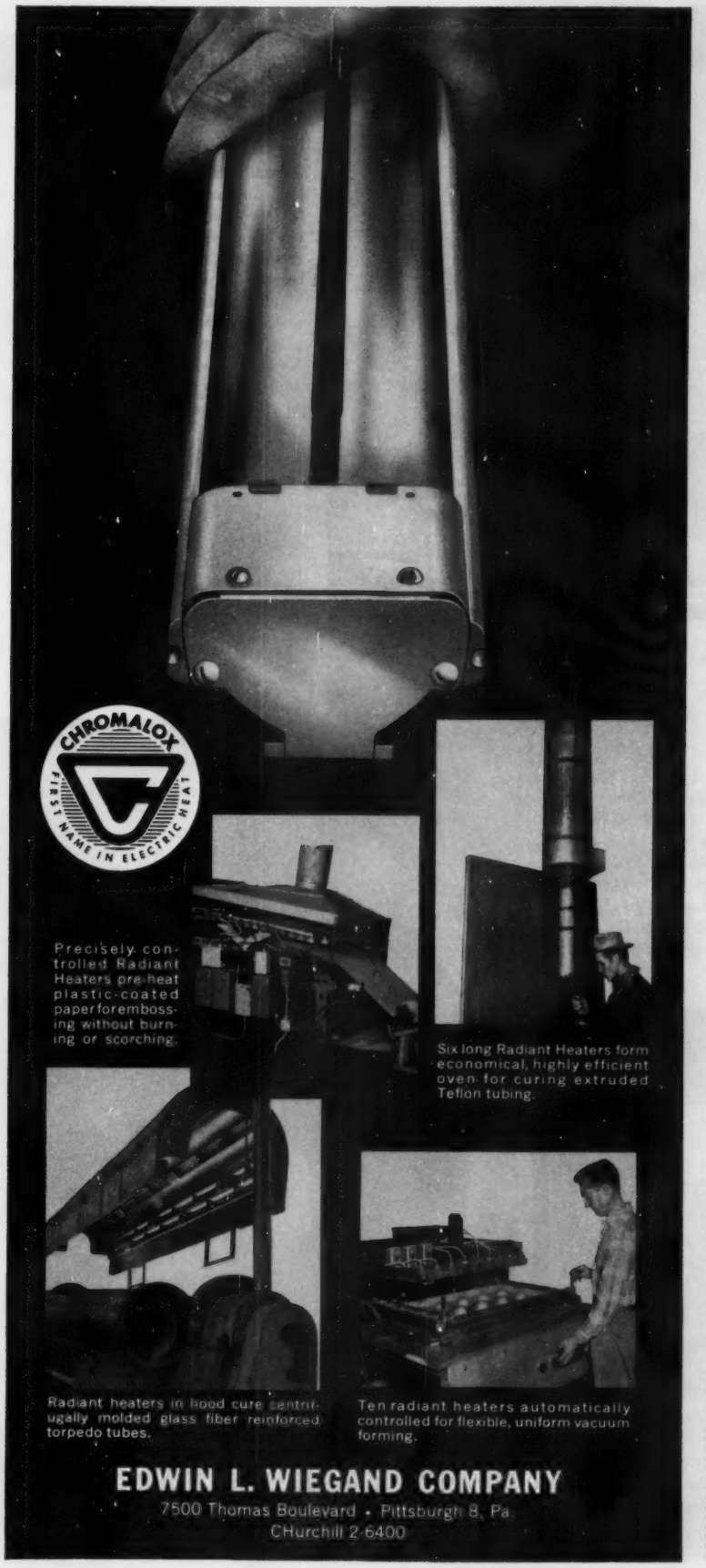
Boasting years of service in earthmoving equipment, a rugged six-cylinder diesel, designed by Caterpillar Tractor Co., will take on the new job of powering highway trucks. Design of the engine features an economical and highly reliable fuel injection system: A precombustion chamber is used, where part of the injected fuel is ignited to ram the main charge into the cylinder under high turbulence. This, according to Caterpillar engineers, assures full burning under all load conditions. The chamber also permits use of a single, large-orifice fuel injector which minimizes fouling problems and maintenance. Weighing in at 2070 lb, the engine develops 220 hp (9.4 lb per hp), has a 525 cu in. displacement.

NSPE Will Certify Engineering Technicians

WASHINGTON — The National Society of Professional Engineers has established an Institute for the Certification of Engineering Technicians and Engineering Technologists. The Institute, exclusively an examining body, will be operated by a board of directors—half registered professional engineers, the other half certified engineering technologists. It will:

- Determine by examination, endorsement, or otherwise, qualifications of all persons who apply for certification.
- Grant a certificate in the appropriate grade to applicants who successfully meet the criteria for certification.

A. C. Friel, chairman of the NSPE Committee on Engineering Technicians, said that the Institute "should provide a much needed means of recognizing the status of technician members of the technological team" and should also "lead to the upgrading of the education and work experience as well as the continued self-development of the technician."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Precisely controlled Radiant Heaters pre-heat plastic-coated paperforembossing without burning or scorching.
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Here's high-intensity heat . . . adjustable from 0 to 100% of heating capacity by fingertip control. Different zones of heat intensity can also be set up . . . by arranging heaters in different "banks" with individual controls for each.

Chromalox Far-Infrared (long wave length) is absorbed almost equally fast by all colors, textures and surfaces . . . including clear glass, plastics, cellophane.

For heating, baking, drying, curing, pre-heating, dehydrating, pre-expanding.

Space-saving, non-breakable, all-metal units withstand knocks, bumps, vibration. Moisture-resistant terminals available. No fumes, flames, glare or leaky pipes. Standard heating lengths to 150 inches. Immediate delivery from stock. Low-cost installation and operation. You can build production line heating tunnels, ovens, banks right on the job.

Write for Bulletin G62. Or, for fast action and on-the-job assistance with your heating problem, call your Chromalox Man listed below. 51874

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Ludlow 9-6321

MIDDLETOWN CONN.
Diamond 6-9606

MILWAUKEE, WIS.
Broadway 1-3021

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NASHVILLE, TENN.
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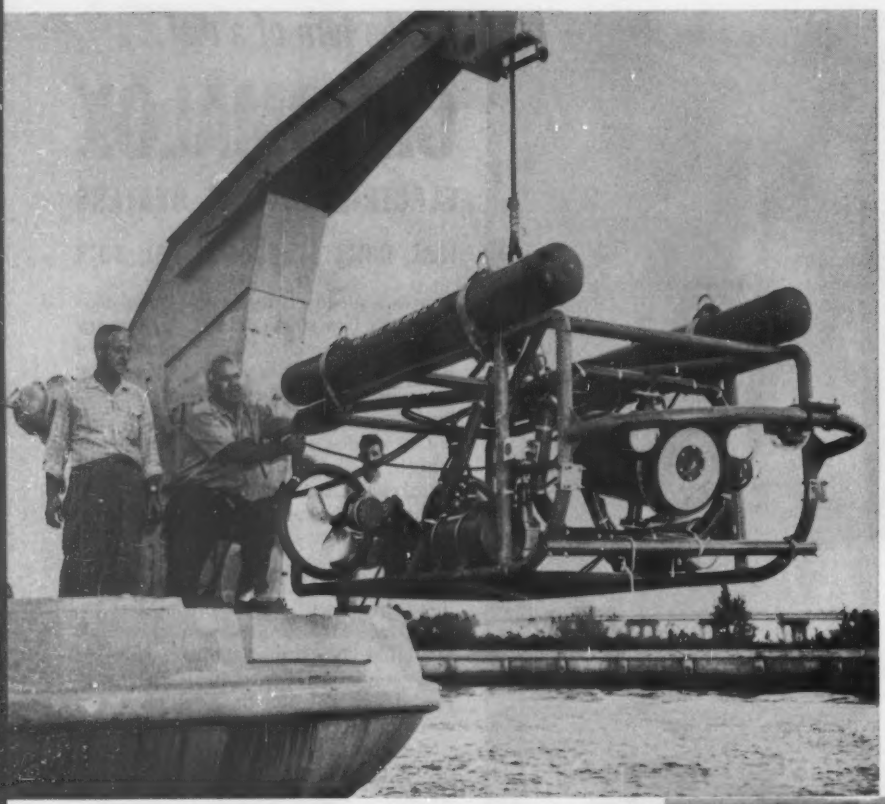
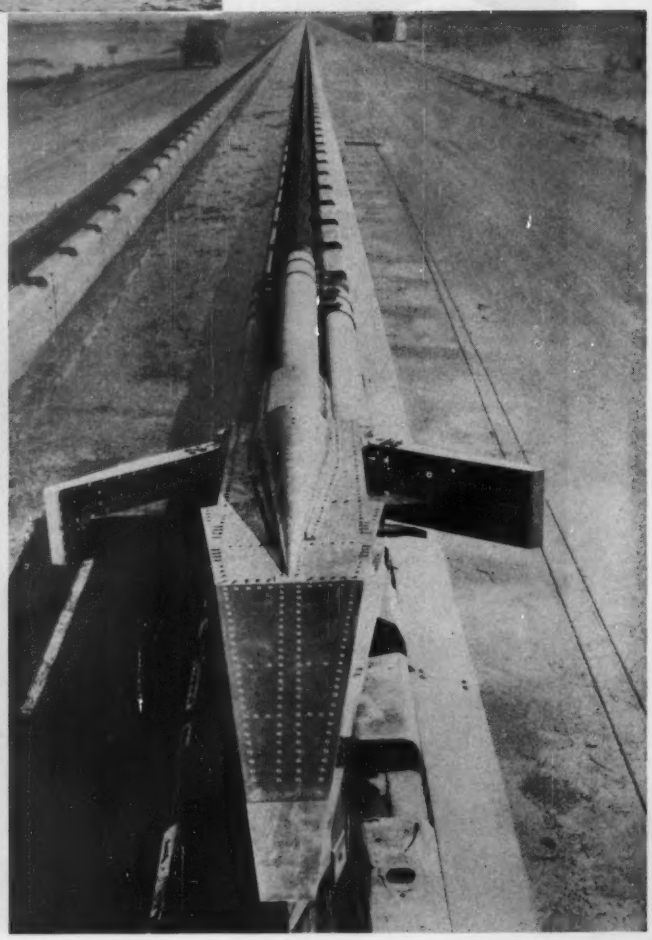


Poised to submerge and do surveying, inspecting, or recovery jobs, MUV (Mobile Underwater Vehicle) can go down to 2000 ft. MUV operates by remote control from a console on a mother ship, where a TV image and data on depth, speed, and underwater light current are displayed. The vehicle, built by Vare Industries, has a propulsion system which allows it to hover at any depth in currents or tides of several knots.

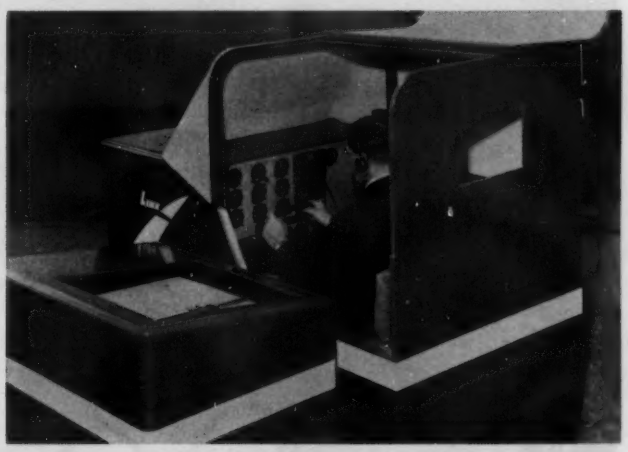


Supersonic monorail sled, built by Northrop Corp. to test inertial guidance system components, reached a speed of 2688 mph in 2 seconds, then braked to a stop in 25,000 ft in its first run at peak velocity. Braking fins open about 2 in. at the instant of rocket burnout, are fanned out to full capacity by the wind blast. Three Grand Central Rocket Co. Javelin solid-fuel rockets propel the sled.

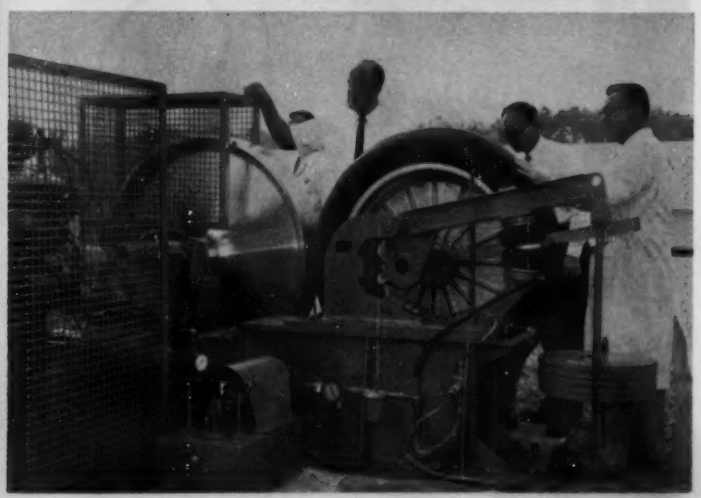
Orange, yellow, green, blue, and white electroluminescent panels for illuminating dials, control panels, etc., are being produced by RCA in several sizes and in voltages of 125, 250, and 600 ac. Low-power, long-life Panelray light emission is uniform, without graininess or hot spots.

Built to transport bananas from plantation to ship, this vehicle operates 12 to 15 in. above ground or water; it should travel over unnavigable rivers and "indifferent roads," according to its builder, Britten-Norman Ltd., England. Cushioncraft is powered by a 170-bhp sports-car engine which drives the large peripheral rotor. Two propellers provide forward thrust.

First new ground trainers for lightplane pilots since World War II have been introduced by Link Div., General Precision Inc. Electronic model, right, has a full complement of instruments and simulates flight up to 8800 ft at speeds from 85 to 220 mph. New radio-aids unit is used with this trainer and a mechanical model.



Aimed at breaking the world speed record (394.196 mph), the jet-propelled Flying Caduseus travels on 48-in. Firestone tires which have proved out at speeds as high as 600 mph. Special rig, which is able to bring the tire up to this speed in 47 seconds, was built to test the tires.



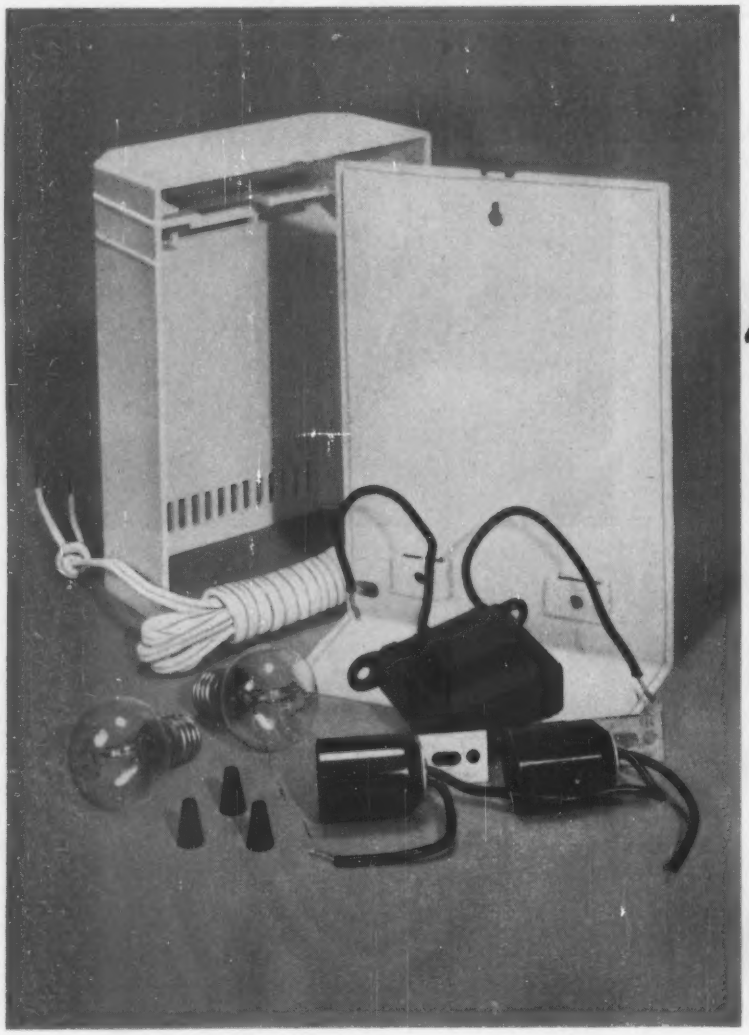
IF YOU'RE READY FOR CUSTOM PARTS

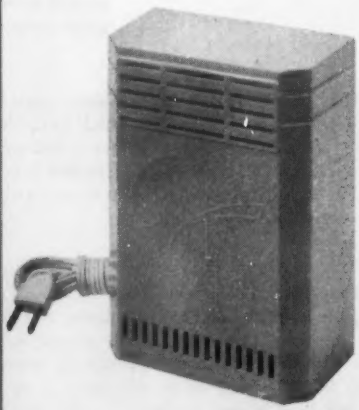
It pays to get complete QC* service by Sylvania

Sylvania helps you with completely objective recommendations for your parts. From long experience in metals, plastics, welds and assemblies Sylvania can take fullest advantage of a wide range of equipment.

Expert design assistance is available and can often improve the quality of your part and, more important, can often help lower the cost of production.

Outstanding quality parts come from the most modern equipment available plus long experience in tooling. In addition, Sylvania practices preventive maintenance for dies and equipment to assure precise uniformity and uninterrupted production.

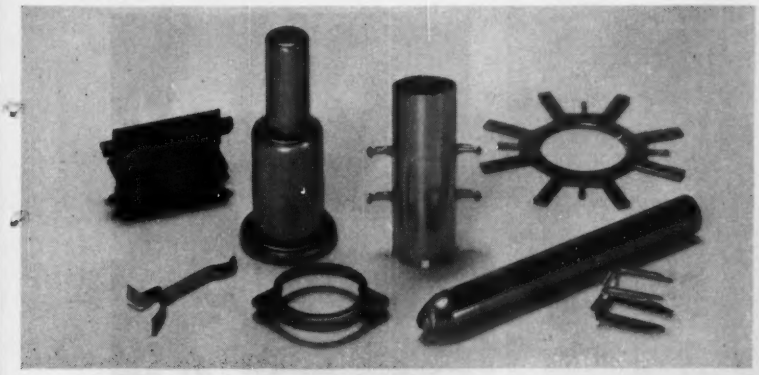




CUSTOM ASSEMBLED

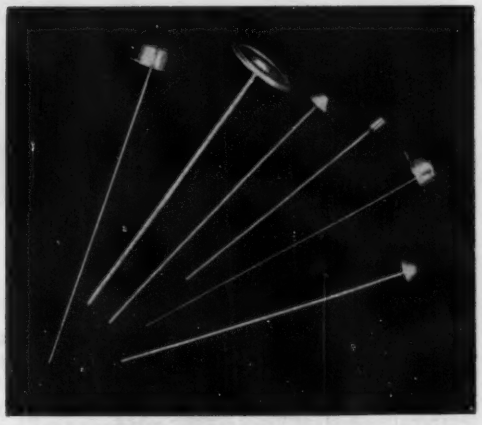
Many of our customers have found Sylvania can often assemble and package a product —at lower cost than they themselves—no matter who *makes* the parts. Subassembly work can also provide customers with additional and unexpected savings.

Result: If your product is small, the parts predominantly plastic and metal, and the quantities 50,000 or more, it pays you to have Sylvania trained specialists assemble it.



FORMED FROM METAL

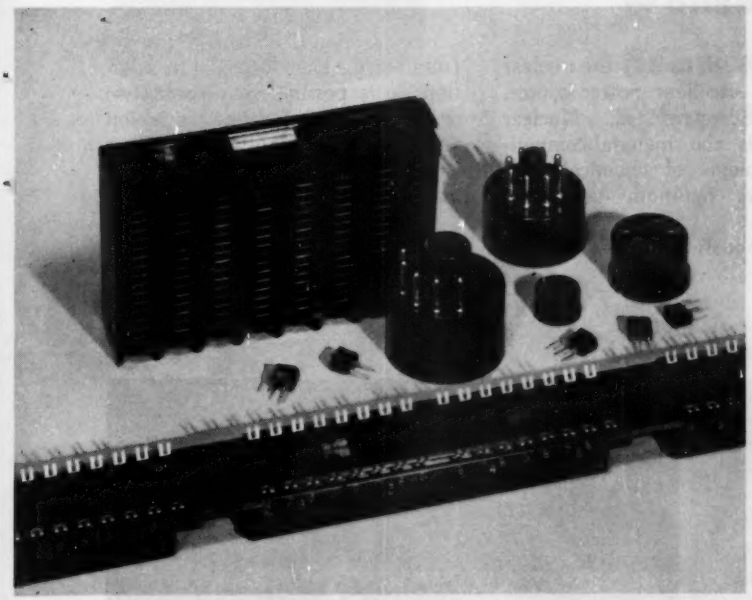
Sylvania maintains complete custom metal stamping facilities and can produce millions of precision-made parts each day from most all types of metal. These parts are available in the desired high-production quantities—to the most exacting specifications—at low cost to you. Sylvania can produce deep-draw eyelet parts, shells, cups and ferrules. Our batteries of multi-slide equipment can produce more than 2 million parts daily. Vertical presses can meet daily production needs of 2 million parts. And special, Sylvania-developed machines can turn out great quantities of small wire and ribbon forms as well as wire cuts and leads.



CUSTOM WELDED

It makes no difference if your part is standard-sized, miniature or subminiature. Welded assembly is a Sylvania specialty. To help you meet your custom assembly needs, Sylvania has developed new high-speed, high-volume welding techniques, advanced welding equipment, automatic and semiautomatic, and a corps of trained specialists.

Results: Sylvania welded assemblies assure high-quality electrical and mechanical contact, mirror-image uniformity and low cost.



MOLDED FROM PLASTICS

Sylvania offers quick, efficient production of plastic parts—and at low piece prices in production quantities. Reason? Sylvania operates one of the most complete lines of modern automatic molding equipment in the world for compression, injection and transfer molding. Our bank of rotary presses can produce more than a million parts a day, is ideally suited to phenolics and urea, and assures minimum cost for simply designed plastic parts.

*QC MEANS QUALITY CONTROL!

Sylvania maintains a complete quality control department to assure that parts are made to your exact specifications. This control works for you throughout the manufacturing cycle. It's just one more way you benefit when you have Sylvania on the job for parts.

For full details or a quote, write Sylvania Electric Products Inc., Parts Division, Warren, Pennsylvania.

SYLVANIA

Subsidiary of **GENERAL TELEPHONE & ELECTRONICS**

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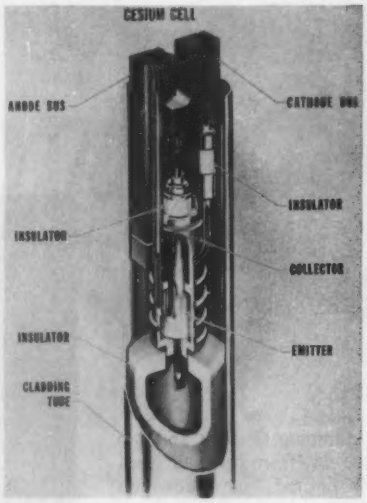
Thermionic Converter Delivers 90 Watts

Operates Directly from Nuclear-Fission Heat

SAN DIEGO, CALIF.—New experiments by General Atomic Div., General Dynamics Corp., have proved nuclear-thermionic systems feasible. Data now show that thermionic converters are capable of producing electricity at high power densities and adequate voltages within a working reactor.

Tests conducted in General Atomic's TRIGA reactor resulted in power outputs as high as 90 watts, power densities of up to 21 watts per sq cm, overall efficiencies in the 10 per cent class, and operating temperatures of around 3500 F. According to Robert C. Howard, who presented the data at a recent AIEE meeting, the converter (a cesium cell) appears capable of further increase in efficiency, once its dimensions and temperatures are optimized. And no attempt has yet been made to utilize waste heat rejected by the device.

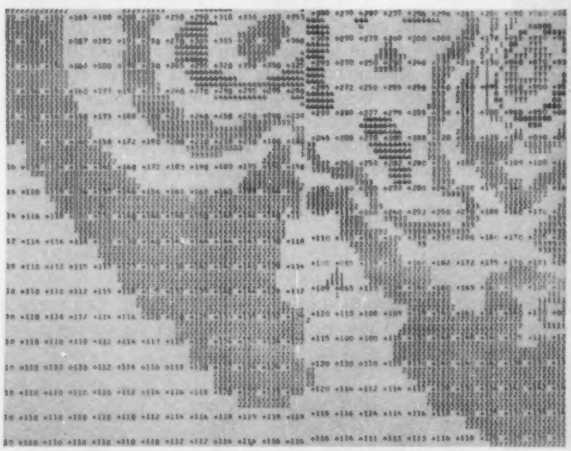
The thermionic cell requires clean high heat, making the nuclear reactor an excellent power source, Mr. Howard continued. Nuclear heat avoids the material-compatibility problems of chemical heat and allows optimum geometries (minimizing heat losses). In addition, it is possible to cascade two or more types of direct-conversion devices: Cesium cells could team with semiconductors to appreciably increase overall efficiency.

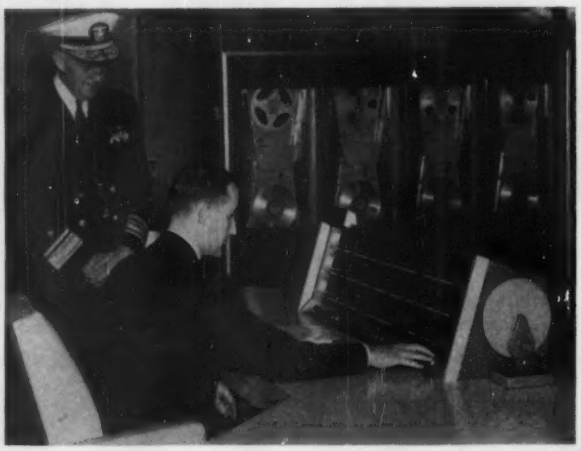


Electrons, boiled out of the emitter by the heat from fissioning uranium, are caught by the current collector surrounding the emitter electrode. Cesium vapor is added in the gap to enhance electron flow. Emitter element measures only ½ in. long.

Nuclear fuel element acts as the emitter in the nuclear-thermionic power system. Fuel used is fully enriched U-235 made by a carbide fabrication technique developed by General Atomic. When in the reactor, the cesium cell is housed like any fuel element.

Weather by the Numbers





Reports from 5000 weather stations are correlated in one hour by Navy's new computerized meteorology system. Before calculating the weather forecast, the computer identifies information received by station, evaluates each report, throws out unreasonable data, and charts the overall picture for Navy meteorologists (portion of a chart, left). Time for the complete operation—from data received to weather forecast ready—is about one hour; the same job would require around-the-clock work from 64,000 data analysts equipped with desk calculators. Although the computer has a large storage capacity, it cannot handle the tremendous amount of information needed for numerical weather forecasting. To fill the gap, four Ampex tape recorders provide "on-line" storage. Navy spokesmen claim that, while the system's first job is to provide reliable forecasts for the fleet, it will also find use as a weather-research tool.

Johnson Powder Metallurgy Bronze or Iron Bearings... Bushings... Parts Offer Many Important Savings

Pre-Lubrication—The porous structure of Johnson powder metallurgy products acts as a reservoir for the lubricant, providing sufficient oil during operation . . . storing it when at rest. This feature often eliminates costly lubricating devices and systems, guards against neglect and assures longer operating life of the unit.

Formed to size—The manufacturing process is essentially a forming and sintering operation. This eliminates machining, prevents scrap, yet provides accuracy at a low unit cost. Uniformity of each bearing, or part, cuts assembly time to a minimum. These are but two of the many money-saving features of Johnson powder metallurgy bearings, bushings, and structural parts. Let us show you how to design your product to take full advantage of this economy yet gain greater performance and longer service life. No obligation of course. Write for literature today.

Johnson Bronze Company

New Castle, Pa.

West Coast Plant: Oakland 8, Calif.

Circle 417 on Page 19

Cars: Mid-60 Powerplants Jockey for Position

SAN FRANCISCO—Still top dog in the auto industry, the gasoline engine is being challenged as never before by two hard-running contenders: The small high-speed diesel and the gas turbine. Barring a major breakthrough in fuel-cell design, which would make electrics look more attractive, or unexpected progress in development of Curtiss-Wright's rotary, diesels and turbines will soon encroach on the otto cycle's private domain. The big question today is what will fit where, and how soon.

Turbine-Powered Cadillacs?

An educated guess, advanced by a prominent British diesel designer, puts gas turbines in some of the larger U. S. cars by 1965. At the recent SAE West Coast Meeting, J. H. Pitchford, manager and technical director of Ricardo & Co. Ltd., said English development work on the gas-turbine car is as far advanced as that in the U. S. But it is likely that the turbine will make its debut over here, "if only for the reason that fuel consumption is a less important factor in the U. S. than in England, particularly among the high-class more expensive cars." U. S. luxury models "lend themselves a good deal better for the application of the turbine . . . and the accommodation of very large fuel tanks."

Diesels for the Fleet

"It is in the utility class that we shall see the small automotive diesel make really striking progress," Pitchford said. Commercial fleets, plus the entire taxicab and delivery-van population of the world's more industrialized countries, will soon be equipped with oil burners. (More than 10,000 diesel-powered buses and taxis now ply the streets of London.) Frequent starting and stopping, a very light mean-load factor, and a large annual mileage comprise ideal diesel conditions.

Contrary to popular belief, fuel economy is no longer the big selling point for diesels. The oil engine's fuel-price edge has practically disappeared because of differential taxation. Certain incidental advantages, which were first neglected, now favor the engine: Greater freedom from breakdown due to trivial causes (electrical faults, for example), and longer periods between major overhauls are two strong points. Flexibility of fuel digestion, which will be even further enhanced with the development of a cheap turbocharger, is another.

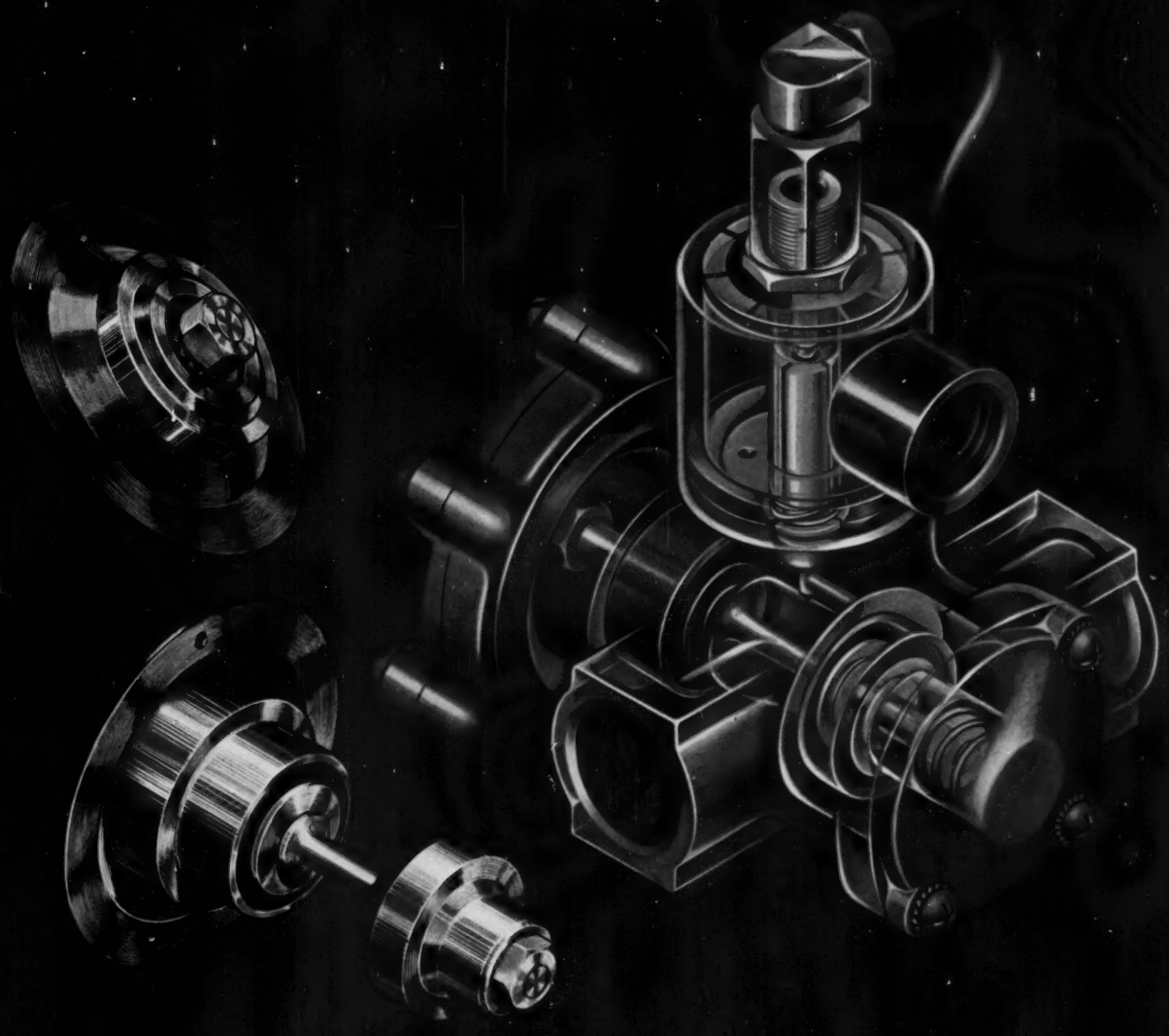
Dominating the coming diesel revolution, according to Pitchford, will be four-cylinder engines in the range of 100 to 150 cu in. swept volume. Turbocharging will be used increasingly, even on these relatively small powerplants. Six-cylinder automotive diesels are likely to appear "if there is a real breakthrough in the search for inexpensive fuel-injection equipment."

Meanwhile, throughout the '60s, the average driver will continue to fill his tank with gasoline. Not only has Detroit's favorite engine been refined to a high degree during its long tenure, but it still is being improved. Any rival powerplant will have to compete with these improved models of the future.

Tri-lingual Computer Aide

Forms in triplicate—but each in a different "language"—can be produced simultaneously by a document-writing system announced recently. In a one-step operation from a key-punch input, the machine produces two typewritten documents, two sets of punched cards, and a punched five-channel paper tape. Designated IBM 850 by International Business Machines, White Plains, N. Y., the machine is serial in operation. That is, one character at a time is sensed and directed through a common channel to activate any output unit that is programed "on". Operating speeds range from 9 to 20 card-columns a second, depending on the particular configuration being used.

Circle 418 on Page 19→



SKINNER *2-way and 3-way Solenoid Valves*

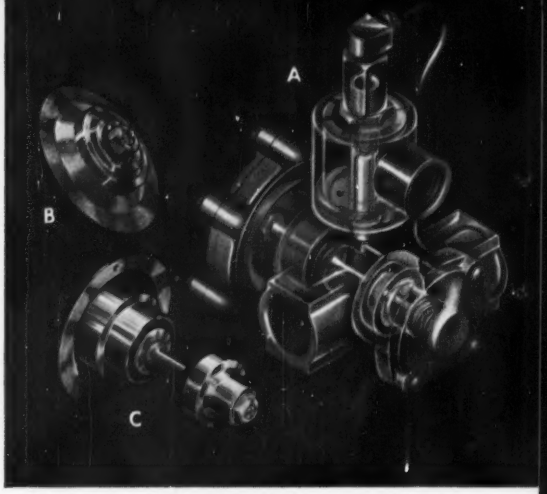
for high flow, heavy-duty industrial use

Skinner combines unique diaphragm assembly and V5 solenoid operator in new L Series valves

Skinner has now combined its famous V5 solenoid operator with a unique diaphragm assembly in a new line of two-way and three-way valves—the versatile L Series.

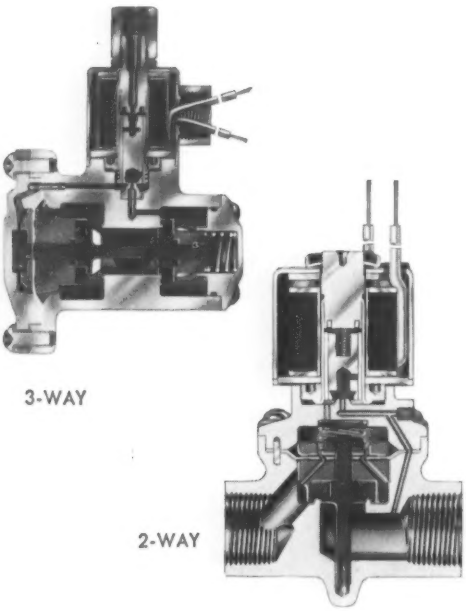
Unusually long life is assured by this new diaphragm assembly. The 3-way diaphragm consists of two tough laminates of nylon fabric coated with a Buna-N rubber separated by a thin Teflon disk. The assembly is virtually 100% supported in the open and closed positions with only a very small area exposed to pressure differential during operation. Life tests show that this type of diaphragm far out-performs all others tested.

The two-way diaphragm and spindle assembly supports a seal retainer and soft, synthetic seal which provides bubbletight sealing of the main orifice. This seal fits on a shoulder which extends beyond the seat and helps to cushion the closing motion—thus minimizing water-hammer.



A—Transparent view of normally closed 3-way solenoid valve
B—Front view of diaphragm assembly
C—Spindle seal retainer and diaphragm assembly

Low cost 2-way and 3-way valves to meet your high flow industrial requirements



Cutaway views of 2-way and 3-way valves showing how the unique diaphragm assembly and solenoid operator are combined in these new valves.

Skinner L Series solenoid valves feature forged naval brass bodies, stainless steel and brass internal parts. They are available normally closed, normally open and directional control in standard and explosion-proof construction.

In addition to the many exclusive features, these Skinner valves are low in price, and with one model—a 2-way normally closed valve—available at especially low budget cost.

All 3-way and 2-way normally open valves are supplied with a piped exhaust return. For catalogs and complete information, contact a Skinner Distributor listed in the Yellow Pages or write us at the address below.

SKINNER L SERIES SPECIFICATIONS

	TWO-WAY	THREE-WAY
Pipe Sizes, NPTF	⅜"*, ½", ¾", 1"	⅜", ½", ¾"
Orifice Sizes	½", ¾", 1"	⅜", ½", ¾"
Operating Pressure Differential — Minimum	5 PSI	5 PSI (⅜" 10 PSI)
Operating Pressure Differential — Maximum	150 PSI	150 PSI
Position	Normally closed, Normally open	Normally closed, Normally open, Directional control
Leakage	Bubbletight	Bubbletight
Temperature Range (Ambient and Media)	Minus 40°F to plus 180°F	Minus 40°F to plus 180°F

*has ½" orifice

When you specify solenoid valves, specify Skinner.

Skinner solenoid valves are distributed nationally.

SKINNER ELECTRIC VALVES

THE CREST OF QUALITY

SKINNER ELECTRIC VALVE DIVISION,
THE SKINNER CHUCK COMPANY • NEW BRITAIN, CONNECTICUT, U.S.A.

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Meetings and Shows

Sept. 12-13—

Material Handling Institute Inc. Fall Meeting to be held at the Cavalier Club, Virginia Beach, Va. Further information is available from Hanson & Shea Inc., 1 Gateway Center, Pittsburgh 22, Pa.

Sept. 12-15—

Society of Automotive Engineers Inc. National Farm, Construction, and Industrial Machinery Meeting, including production forum and engineering display, to be held at the Milwaukee Auditorium, Milwaukee. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Sept. 15-16—

American Society of Mechanical Engineers. Engineering Management Conference to be held at the Morrison Hotel, Chicago. Additional information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 18-21—

American Society of Mechanical Engineers. Petroleum - Mechanical Engineering Conference to be held at the Jung Hotel, New Orleans, La. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 19-20—

Steel Founders' Society of America. Fall Meeting to be held at the Homestead, Hot Springs, Va. Additional information is available from society headquarters, 606 Terminal Tower, Cleveland 13, Ohio.

Sept. 21-23—

American Society of Mechanical Engineers - American Institute of Electrical Engineers. Power Conference to be held at the Bellevue-Stratford Hotel, Philadelphia. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Sept. 26-29—

American Welding Society. Fall Meeting to be held at the Penn-Sheraton Hotel, Pittsburgh. Additional information is available from AWS headquarters, 33 W. 39th St., New York 18, N. Y.

Sept. 26-30—

Instrument Society of America. Instrument-Automation Conference and Exhibit and 15th Annual Meeting to be held in the Coliseum, New York. Additional information can be obtained from ISA headquarters, 313 Sixth Ave., Pittsburgh 22, Pa.

Sept. 27-30—

American Rocket Society Inc. Space Power Systems Conference to be held at the Miramar Hotel, Santa Monica, Calif. Additional information can be obtained from society headquarters, 500 Fifth Ave., New York 36, N. Y.

Sept. 27-30—

Association of Iron and Steel Engineers. Exposition and Convention to be held at the Auditorium Hotel, Cleveland. Further information is available from AISE headquarters, 1010 Empire Bldg., Pittsburgh 22, Pa.

Oct. 9-12—

American Society of Mechanical Engineers. Rubber and Plastics Conference to be held at the Lawrence Hotel, Erie, Pa. Further information can be obtained from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Oct. 9-14—

American Institute of Electrical Engineers. Fall General Meeting to be held at the Morrison Hotel, Chicago. Additional information is available from AIEE headquarters, 33 W. 39th St., New York 18, N. Y.

Oct. 10-11—

Sixth Conference on Mechanisms to be held at Purdue University, Lafayette, Ind. Conference is sponsored by Purdue and MACHINE DESIGN. Further information is available from Editor, MACHINE DESIGN, Penton Bldg., Cleveland 13, Ohio.

Oct. 10-12—

National Electronics Conference to be held at the Hotel Sherman,

(Please turn to Page 42)

Theme Tower Symbol of the 1960 Metal Show

Learn a lot about design at the

NEW METAL SHOW!

"The problem of keeping abreast of new developments in today's rapidly changing technology is always difficult. The Metal Show, through its audio-visual presentations of current advances in knowledge, presents a time-condensed package for those interested in metals engineering and processing."

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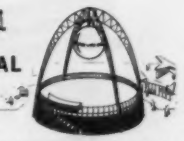
October 17-21

NATIONAL METAL CONGRESS and EXPOSITION



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Circle 419 on Page 19

←Circle 418 on Page 19

You get these benefits...

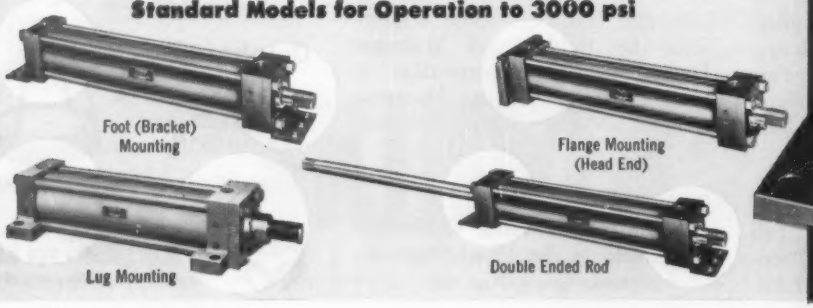
- ✻ **prompt delivery**
- ✻ **competitive pricing**
- ✻ **any external mounting to meet your requirements**

When you BUY VICKERS HYDRAULIC CYLINDERS

Don't miss Booth 107 Production Engineering Show Navy Pier, Chicago, Sept. 6-16

Typical of custom designs that can be furnished readily from Vickers new cylinder facility is this model built with extra rigidity and strength at both rod and clevis ends to overcome side loadings. For added corrosion resistance, stainless steel clevis pins, piston rods, retaining screws and grease fittings are used.

Standard Models for Operation to 3000 psi



Choose the cylinder "outside" that's best for your installation—Vickers offers you a wide selection of standard mountings plus an almost unlimited range of special configurations. Alternate rod end threads . . . straight thread port connections . . . extra barrel lengths for bearing support . . . are among many available options.

- Working pressures to 3000 psi (non-shock)
- Hard chrome plated, ground and polished, high-strength alloy steel piston rods.
- Large ports hold pressure drop within desirable limits.
- Fast, accurate parts replacement is assured because all cylinders are individually registered.
- Honed barrels of heavy walled seamless tubing minimize friction and wear.
- Cushions can be provided—either head, rod or both ends.
- Your choice of automotive step-cut piston rings for maximum life or low friction "T" rings for applications requiring minimum leakage. Full size cast iron piston for maximum bearing support with either type seal.
- Synthetic rubber wiper ring is standard—metallic wipers available.
- Two large wrench flats on rod are standard—additional flats available on request.
- Fully meet JIC specifications.

New, separate plant facilities—devoted exclusively to the design and manufacture of hydraulic cylinders—assure prompt individual attention to your orders. Service stocks are maintained at all Vickers warehouses in the U.S. and Canada. For more application data and installation dimensions, call or write today for Bulletin 60-68

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SPHERCO®
BEARINGS

If you have applications involving linkage or transfer of motion, SPHERCO Bearings can supply your needs in a wide variety of materials with a quality that will give you top performance under normal or high temperature conditions.

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Circle 421 on Page 19

(Continued from Page 39)

Chicago. Sponsors include American Institute of Electrical Engineers, Institute of Radio Engineers, Illinois Institute of Technology, Northwestern University, and University of Illinois. Further information can be obtained from NEC headquarters, 228 N. La Salle St., Chicago 1, Ill.

Oct. 10-14—

Society of Automotive Engineers Inc. National Aeronautic Meeting, including manufacturing forum and engineering display, to be held at the Ambassador Hotel, Los Angeles. Additional information can be obtained from SAE headquarters, 485 Lexington Ave., New York 17, N. Y.

Oct. 12-14—

American Vacuum Society. Seventh National Symposium to be held at the Cleveland-Sheraton Hotel, Cleveland. Further information is available from society headquarters, P. O. Box 1282, Boston 9, Mass.

Oct. 12-14—

Gray Iron Founders' Society. 32nd Annual Meeting to be held at the Netherland Hilton Hotel, Cincinnati. Further information is available from society headquarters, National City-E. Sixth Bldg., Cleveland 13, Ohio.

Oct. 14-15—

American Society for Quality Control. 15th Midwest Conference to be held at the Broadview Hotel, Wichita, Kans. Further information can be obtained from the program and publicity vice-chairman, Howard K. Mitchell, 602 S. Brookside, Wichita 18, Kans.

Oct. 17-19—

The Magnesium Association. Annual Convention to be held at the Pick-Carter Hotel, Cleveland. Additional information can be obtained from association headquarters, 122 E. 42nd St., New York 17, N. Y.

Oct. 17-19—

American Society of Mechanical Engineers — American Society of Lubricating Engineers. Lubrication Conference to he held at the Statler Hilton Hotel, Boston. Further information is available from Meetings Dept., ASME, 29 W. 39th St., New York 18, N. Y.

Short Courses and Symposia

Sept. 19-30—

Technical Report Writing for Engineers and Scientists Seminar to be held at Pennsylvania State University. Lecture, discussion, and workshop sessions will cover all phases of technical report preparation. Further information is available from Conference Center, The Pennsylvania State University, University Park, Pa.

Sept. 21-22—

Industrial Electronics Symposium, sponsored by American Institute of Electrical Engineers and Institute of Radio Engineers, to be held at the Manger Hotel, Cleveland. Further information is available from AIEE, 33 W. 39th St., New York 18, N. Y.

Oct. 4-7—

Eighth Annual Human Engineering Institute to be conducted by Dunlap & Associates, Stamford, Conn. Program will include three days of technical sessions, a half-day on management and contractual aspects of human engineering efforts, and opportunity for private conferences. Further information can be obtained from Dunlap & Associates, 429 Atlantic St., Stamford, Conn.

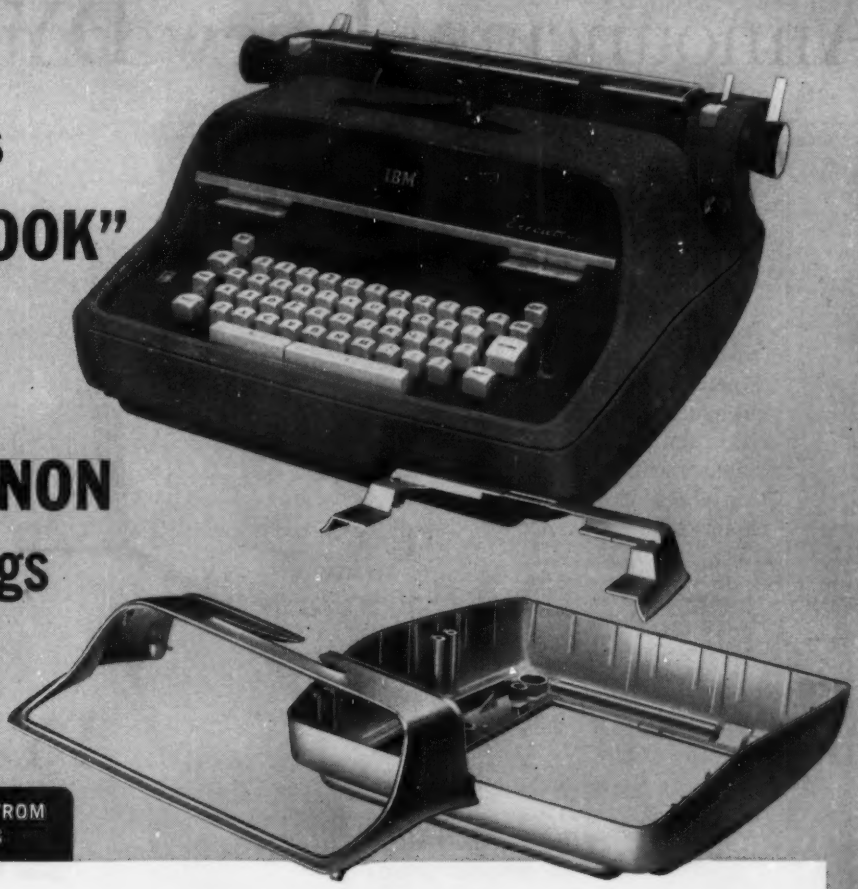
Oct. 14-15—

Revolution in High-Speed Processing Symposium to be held by the Society of Photographic Scientists & Engineers in Washington, D. C. Short access time, compact, simplified photographic processing equipment will be discussed. Further information can be obtained from SPSE, Box 1609, Main Post Office, Washington, D. C.

Oct. 20-21—

National Symposium on Hypervelocity Techniques, sponsored by the Institute of the Aeronautical Sciences, to be held at the Shirley-Savoy Hotel, Denver. Additional information can be obtained from IAS headquarters, 2 E. 64th St., New York 21, N. Y.

IBM®'s "NEW LOOK" enhanced with MT. VERNON Die Castings



CASE HISTORIES FROM MT. VERNON FILES

Behind the sleek silhouette of the dramatically new IBM electric typewriters is "more than a quarter of a century of experience . . . a combination of styling and engineering advances" that promise — and deliver — better performance and easier typing.

For its enclosure IBM knew what it wanted: a new high in eye-pleasing design combined with the many low cost, production benefits of die-casting. It was only natural that, for these die castings, once again, they turned to Mt. Vernon, a reliable supplier to IBM for over 25 years.

And, once again, they found Mt. Vernon's co-ordinated four-fold service — designing, die making, casting, and machining—equal to the job of meeting their strict requirements: strong, gracefully arched, thin-walled, large aluminum sections that match and fit perfectly. The three castings that cradle and enclose the intricate typewriter mechanism are delivered completely machined, ready for finishing.

Like IBM, leading manufacturers in all industries know and rely on Mt. Vernon's experienced use of its complete facilities for die cast zinc and aluminum parts ready for assembly. These services, all under one roof in 200,000 square feet of space, may hold the answer to your design and production problems. Think about it . . . and let us know. We'll gladly talk it over, without obligation. Just call your nearest Mt. Vernon sales representative.

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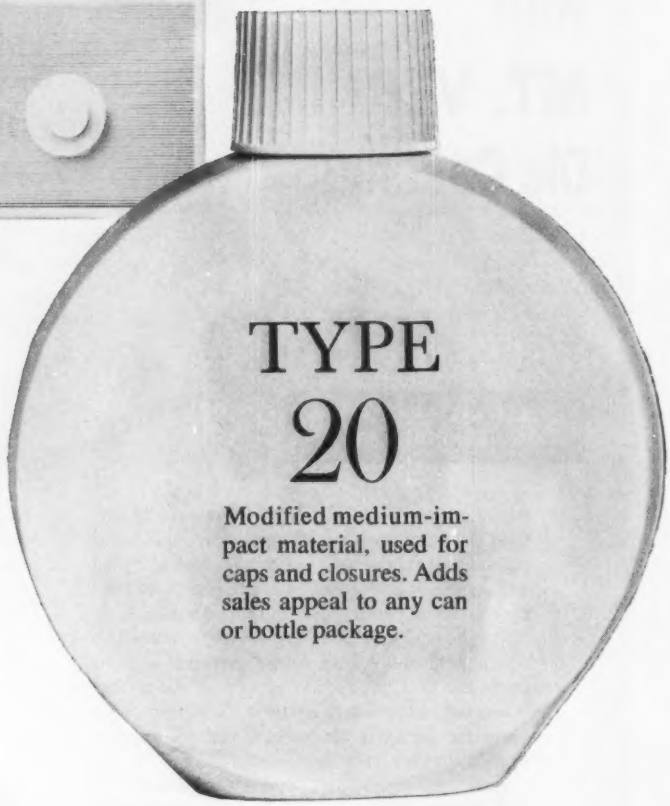
Circle 422 on Page 19

Announcing 4 new DYLENE®

TYPE 9

A new high heat-resistant material, can pass a rigid oven test (95° for 7 hours) without distortion. Ideal for radio cabinets.



TYPE 20

Modified medium-impact material, used for caps and closures. Adds sales appeal to any can or bottle package.

Other members of the DYLENE polystyrene family are:

Normal DYLENE polystyrenes:

TYPE 2: Easy to mold. Ideal for use with large and/or small, intricate mold designs. Can be used for clear, throw-away containers.

TYPE 3: Fine molding characteristics make it good for general uses where moderate heat resistance is necessary, such as watch cases.

TYPE 4: Use when easy flow and fast setup are important. Good for wall tile.

TYPE 8: Used in TV lens. Heat distortion temperature of 200° F. Has excellent electric and mechanical properties. Good molding characteristics.

Medium shock-resistant DYLENE polystyrenes:

TYPE 30: For appliance parts and closures. Easy to mold. Typical heat distortion temperature of 175°F.

TYPE 80: Ideal for camera parts. Heat-resistant medium-impact material.

High shock-resistant DYLENE polystyrenes:

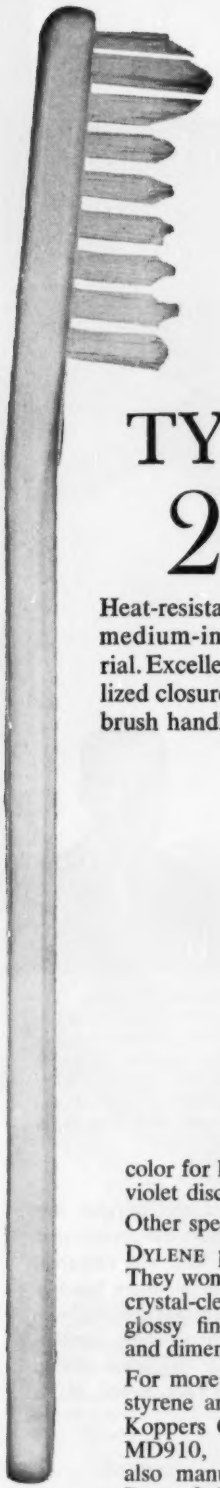
TYPE 200: Impact-resistant, easy to mold. Ideal for for large parts such as refrigerator door liners, appliance housings, etc.

TYPE 201: Especially designed for sheet extrusions where high luster without overlay is desired.

TYPE 800: A high-impact material with good moldability. A heat-distortion temperature of 195°F. Used in air conditioner grilles.

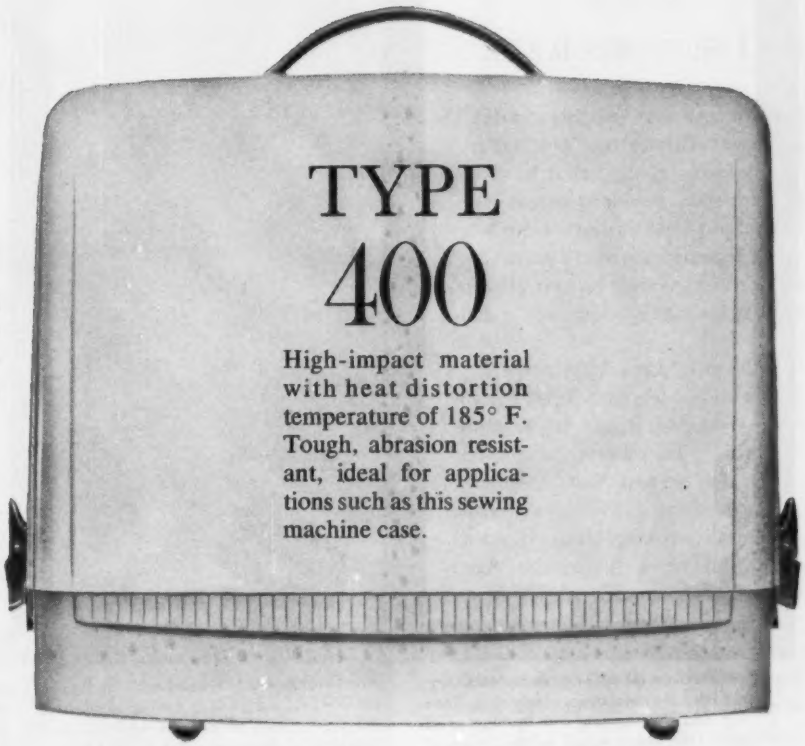
EVENGLO® polystyrene: A series of polystyrenes specially pigmented for interior lighting fixtures. Provides control of light transmission, diffusion, and

polystyrene formulas



TYPE 28

Heat-resistant, modified medium-impact material. Excellent for metallized closures and tooth brush handles.



TYPE 400

High-impact material with heat distortion temperature of 185° F. Tough, abrasion resistant, ideal for applications such as this sewing machine case.

color for long, useful life; stabilized to resist ultraviolet discoloration.

Other special modified formulations upon request.

DYLENE polystyrenes can take rough treatment. They won't chip or shatter. These polystyrenes are crystal-clear or colorful, and they have a hard, glossy finish. They're lightweight, heat-resistant, and dimensionally stable.

For more information on versatile DYLENE polystyrene and other fine Koppers plastics, write to Koppers Company, Inc., Plastics Division, Dept. MD910, Pittsburgh 19, Pennsylvania. Koppers also manufactures DYLAN® polyethylene, SUPER DYLAN® high-density polyethylene and DYLITE® expandable polystyrene.

KOPPERS PLASTICS

Circle 423 on Page 19

Miniature Soldiers. Army ants carry out intricate maneuvers of wheeling, flanking, and envelopment with faultless precision. Their columns are led by "majors", preceded by "scouts". Raids are conducted by "skirmishers". Between campaigns, they form "bivouacs". Army ants are nature's tiny troopers.

Miniature Ball Resolver, approximately 3⅜" x 2½" O.D. continuously calculates position of aircraft and missiles traveling at supersonic speeds. MPB bearings at critical points keep torque low, and help make possible an accuracy of 0.33 of 1%. This is another man-made miracle in miniaturization.

Man with Miracle. This is Dick Anderson, one of MPB's Sales Engineers, whose cooperation with customers includes expert aid in the application of miniature and instrument bearings. MPB's technical staff, most experienced in its field, can assist you with your own miracles in miniaturization.

Miracles in Miniaturization

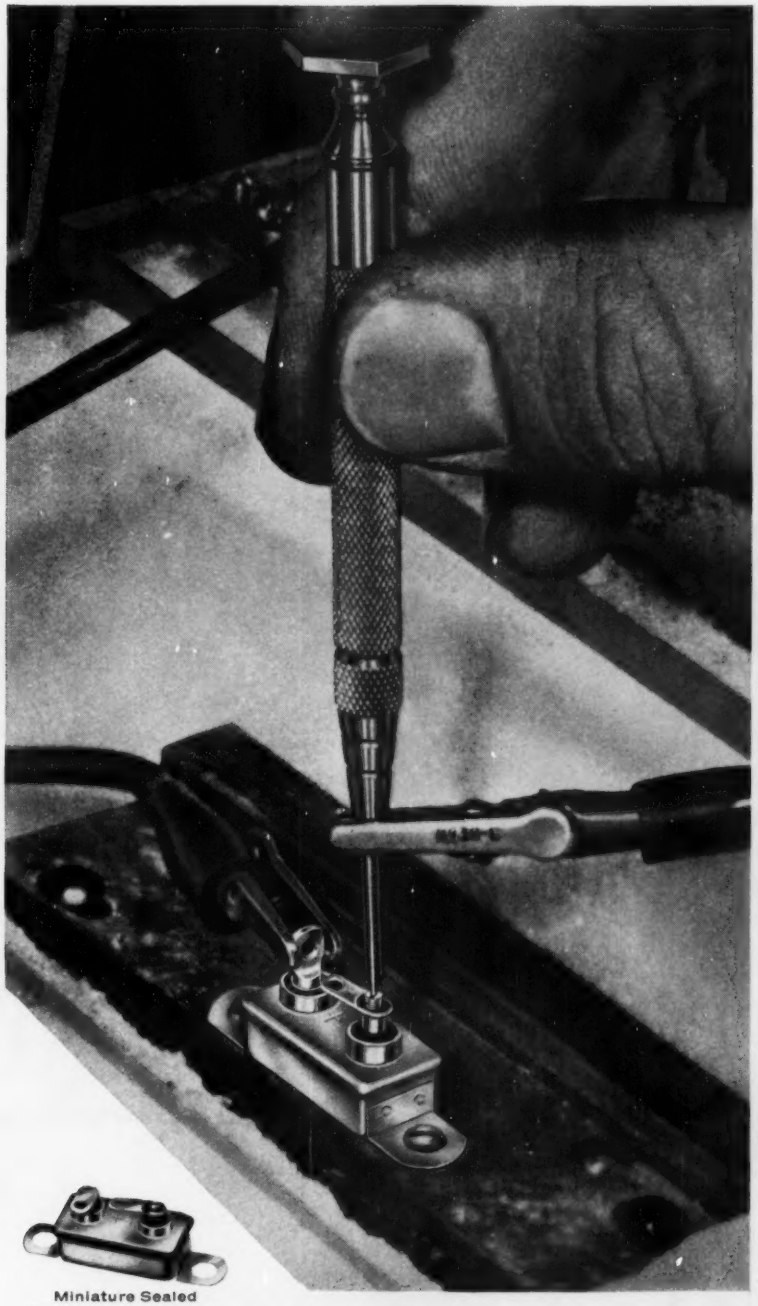
ACTUAL SIZE OF THE MPB BEARINGS IN BALL RESOLVER SHOWN ABOVE

Every day man's advances, both on this planet and beyond, are opening new and challenging areas of application for miniature components and mechanisms. And at each step forward, MPB is ready to help with research, engineering and manufacturing facilities unsurpassed in the miniature bearing industry. MPB makes more than 500 types and sizes of bearings ranging from ⅜" O.D. down, meeting requirements of the most exacting nature. Specials developed on request. For a confab on design problems or our latest catalog write **Miniature Precision Bearings, Inc.,** 89 Precision Park, Keene, N. H.

MPB *Helps you perform miracles in miniaturization*

Circle 424 on Page 19

Tested To "Take It" on Missiles or Machines...



Miniature Sealed
THERMOSWITCH Unit
(actual size)

The Fenwal Miniature Sealed THERMOSWITCH® Unit

Here's the tiny temperature controller that's successfully handling some of today's toughest temperature control problems . . . in missiles and rockets as well as on production machines. Photo shows one of many quality control tests to insure product performance. *It's built to take a beating!*

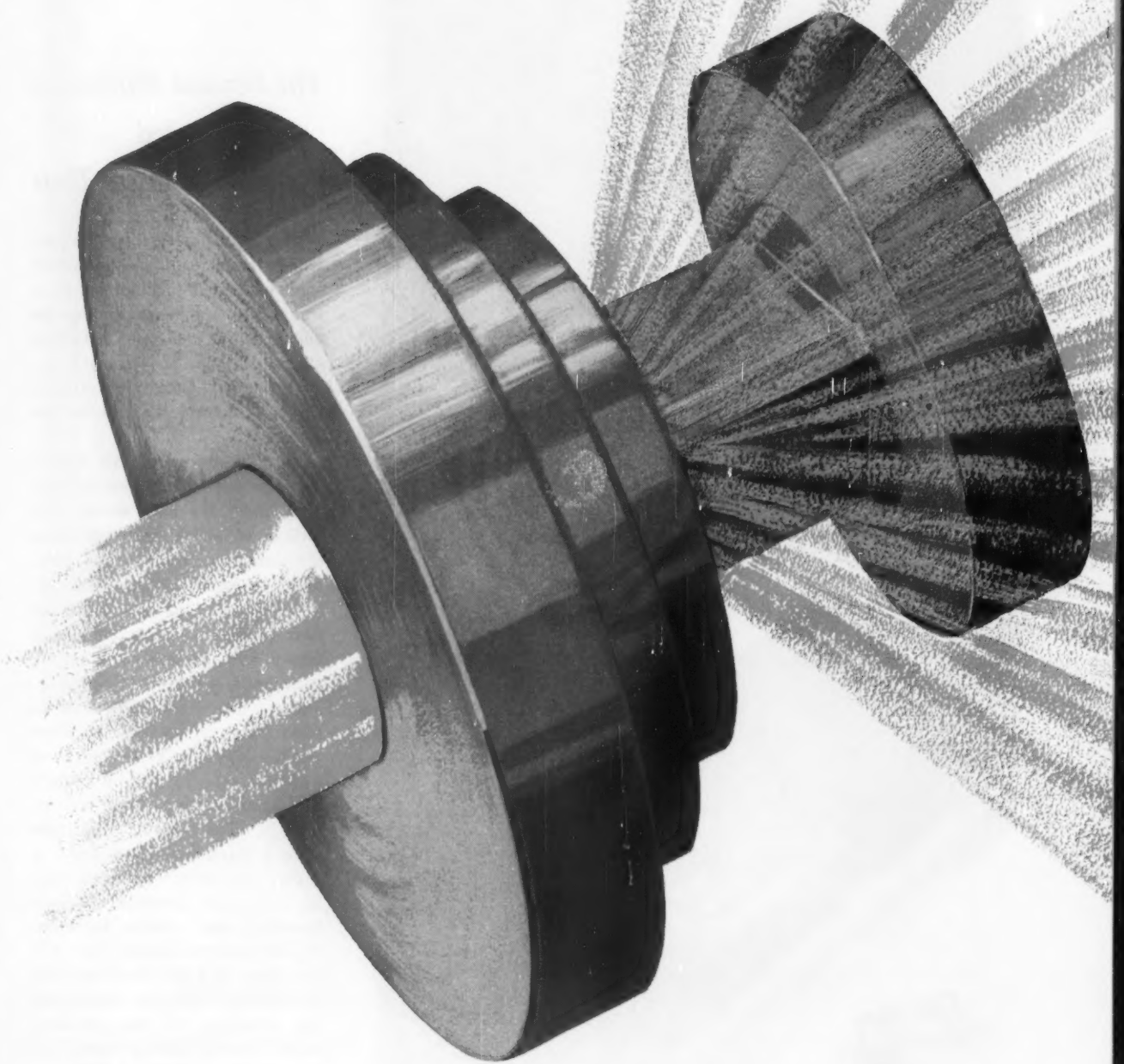
Hermetically sealed, its rugged design permits normal control action even under the most severe conditions of shock and vibration. Stainless steel case is the heat-sensitive element . . . responds with instantaneous, positive action to heat changes of a fraction of a degree. Unit controls to extremely close limits. *Weighs less than ⅛ oz.!*

Easily set for *control* of temperatures from −20 to +200°F. When used as *high limit* switch, range is −20 to +275°F. Can withstand continuous exposure from −65 to +325°F. The Fenwal Miniature Sealed THERMOSWITCH Unit is widely used for crystal ovens, tuning forks, gyro assemblies, missile blankets, and missile batteries. Current rating: 2.5 amps, 115 VAC, 2.0 amps, 28 VDC. Find out how this advanced controller can protect the reliability of your product. Write Fenwal Incorporated, 1910 Pleasant Street, Ashland, Mass.

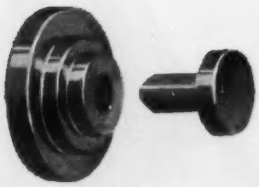
Another example of how **Fenwal** CONTROLS TEMPERATURE . . . PRECISELY

Circle 425 on Page 19

FOR THE MACHINERY PART



THAT TAKES THE BEATING



Liquids forced at high pressure through restricting valves—of HAYNES STELLITE alloy! That's the modern way by which hundreds of products are homogenized today, to make better dairy, chemical, food, and textile products, to name a few.

HAYNES alloys have been a standard material for homogenizer valves for 25 years. Valves that remain free from roughness, porosity, sharp corners, pits. Valves that retain their dimensions where pressures may reach 15,000 psi, and liquid velocities exceed 30,000 ft. per minute. Valves that keep products clean and free from contamination and give long service despite corrosive and abrasive conditions.

If design and production in your field call for tough metal parts, look into HAYNES alloys. There are more than 15 to choose from including HAYNES STELLITE cobalt-base alloys, HAYNES iron-base alloys, HAYSTELLITE cast tungsten carbide, and HASTELLOY nickel-base alloys. They are available as castings, forgings, completely fabricated parts, or as sheet and bar stock. All parts can be furnished machined or ground to specified size and finish.

Our engineers will help you pick the right HAYNES alloy to resist practically any condition of wear, heat, or corrosion. For more information write for descriptive literature.

HAYNES Alloys *will do the job!*

HAYNES ALLOYS

HAYNES STELLITE COMPANY

Division of
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UNION CARBIDE

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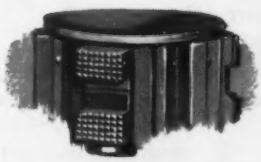
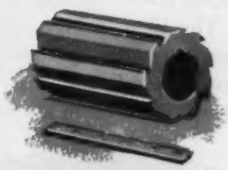
TYPICAL "HAYNES" ALLOY MACHINERY PARTS



Chuck inserts of HAYNES STELLITE alloy last up to 50 days—2 shifts daily—holding heavy pieces during a cut-off operation.

Seam rollers on milk-can machines turn out 2 to 3 times as many cans now that the rollers are made of HAYNES STELLITE alloy.



Cutters and bed knives made of HAYNES STELLITE alloy stay clean and sharp for years while pelletizing extruded polystyrene.

Circle 426 on Page 19

Another new development using

B.F.Goodrich Chemical *raw materials*

ULOK Brand Cube-Type Filters, developed by Union Carbide Development Company, a Division of Union Carbide Corporation, New York, N. Y., offer the face area of a 30" x 30" air filter in the frontal area of a standard size filter, 20" x 20". Non-woven material is Dynel modacrylic fiber bound with Geon vinyl latex by Fiber Bond Corporation, Chicago, Illinois. B. F. Goodrich Chemical Company supplies the Geon vinyl latex.

New, cube-shaped air filters use non-woven made with Geon

The unusual shape of this new replacement air filter is planned to take advantage of a fibrous filter medium of uniform density—a non-woven construction made with Geon vinyl latex as a binder. The cube shape presents more filtering surface to the air stream, providing far higher efficiency over far longer life.

The filter design demonstrates how the unusual balanced physical properties of Geon latex as a binder can pay off. Geon is responsible for the resilience and strength in the batt, allowing the material to be cut, sewed, and formed into the required shape while still maintaining its 2" loft.

Here's another example of the way that versatile Geon vinyl can help to improve a product or open new markets. For more information about Geon and the many different ways you can use it, write Dept. GW-5, B.F.Goodrich Chemical Company, 3135 Euclid Avenue, Cleveland 15, O.

Geon VINYLS

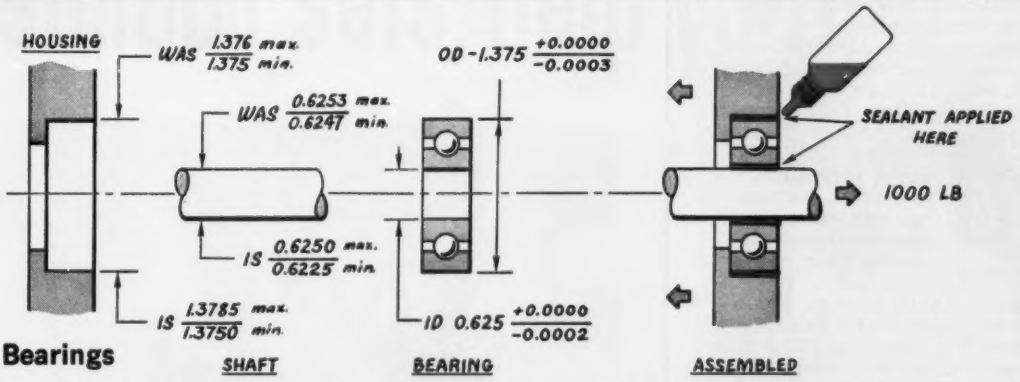
B.F.Goodrich Chemical Company
a division of The B.F.Goodrich Company

B.F.Goodrich

GEON vinyls • HYCAR rubber and latex • GOOD-RITE chemicals and plasticizers

SIMPLIFY ASSEMBLY...
Retain parts on shafts with slip fit and Loctite

Designing with liquid LOCTITE eliminates press fits, shrink fits, broaching, knurling, keyways, set screws and pinning ... provides easier tolerances ... cuts rejects and rework.

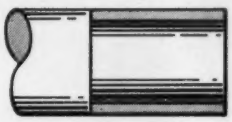


Bearings

LOCTITE Sealant replaced press fit, opening up tolerances .002 inch on shaft and housing. Rejects were cut from 8% to 1% and rework from 20% to 0! Bond to inner race withstands 1000 lbs. thrust ... equal to the best press fit. Slip fit with LOCTITE gives more uniform retention ... eliminates fretting damage due to loose "press fit" or bearing distortion resulting from tight press fit ... assures better shaft alignment. Easier tolerances speed assembly.

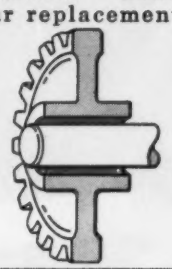
Hardened Sleeves

Eliminates shrink fit ... mounts hardened sleeve without pulling temper.



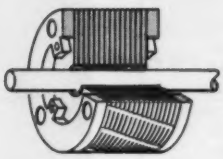
Gears and Pulleys

Eliminates broaching, knurling, shaft distortion. Easier gear replacement.



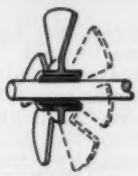
Rotors

Eliminates shaft distortion and resulting regrinding & straightening.



Fans

Eliminates set screws ... no amount of vibration will loosen part.



LOCTITE Sealant is easy to apply... simple to automate

LOCTITE is a one-component liquid with the unique property of converting to a tough plastic when confined between close fitting metal parts. It does not air dry. It does not require mixing with a catalyst and will not spoil on standing in a storage vessel. It comes fully prepared ... stores for years ... hardens only when treated parts are assembled. It forms a tough seal that resists heat, oil, water, all common solvents. Parts treated with LOCTITE can be disassembled by ordinary methods.

LOCTITE Kit No. 10-10

Contains 10 grades of Loctite Sealant specially put up to assist designers in determining proper grade and use of Loctite in product development and for general experimental work. By selection of proper grade, the designer can apply a predetermined amount of locking torque.

Write for literature and free sample capsule.

LOCTITE® SEALANT AMERICAN SEALANTS CO. 111 Woodbine St., Hartford 6, Conn.

Over 1000 stock models of Onan Electric Plants! Expert modification if you need it

Wherever you need independent electrical power for equipment on the move—or equipment headed for use in remote areas not served by highline power—you need an Onan Plant.

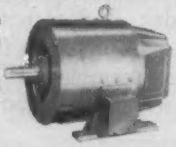
500 WATT ONAN

Over 1000 different models—from 500 to 230,000 watts, with a large variety of starting systems—give you extensive leeway in solving your product's power problem. And every Onan Electric Plant carries the exclusive Onan Performance Certified Tag, assuring you and your customers that every Onan will deliver all the power output promised by its nameplate. Onan's Performance Certification is giving numerous Original Equipment Manufacturers added sales appeal. Let Onan help sell *your* product.

230,000 WATT ONAN

On Power Shovels and Draglines, Maintenance and Service Trucks, Boats, Mobile Communications Trucks, Sales Demonstration Vans . . . to name but a few applications . . . you'll find Onan on the job. You'll find, too, a wide variety of Onan accessories. Various starting systems. Trailers. Various fuel systems. Automatic controls, etc. Each designed for superior performance in your equipment.

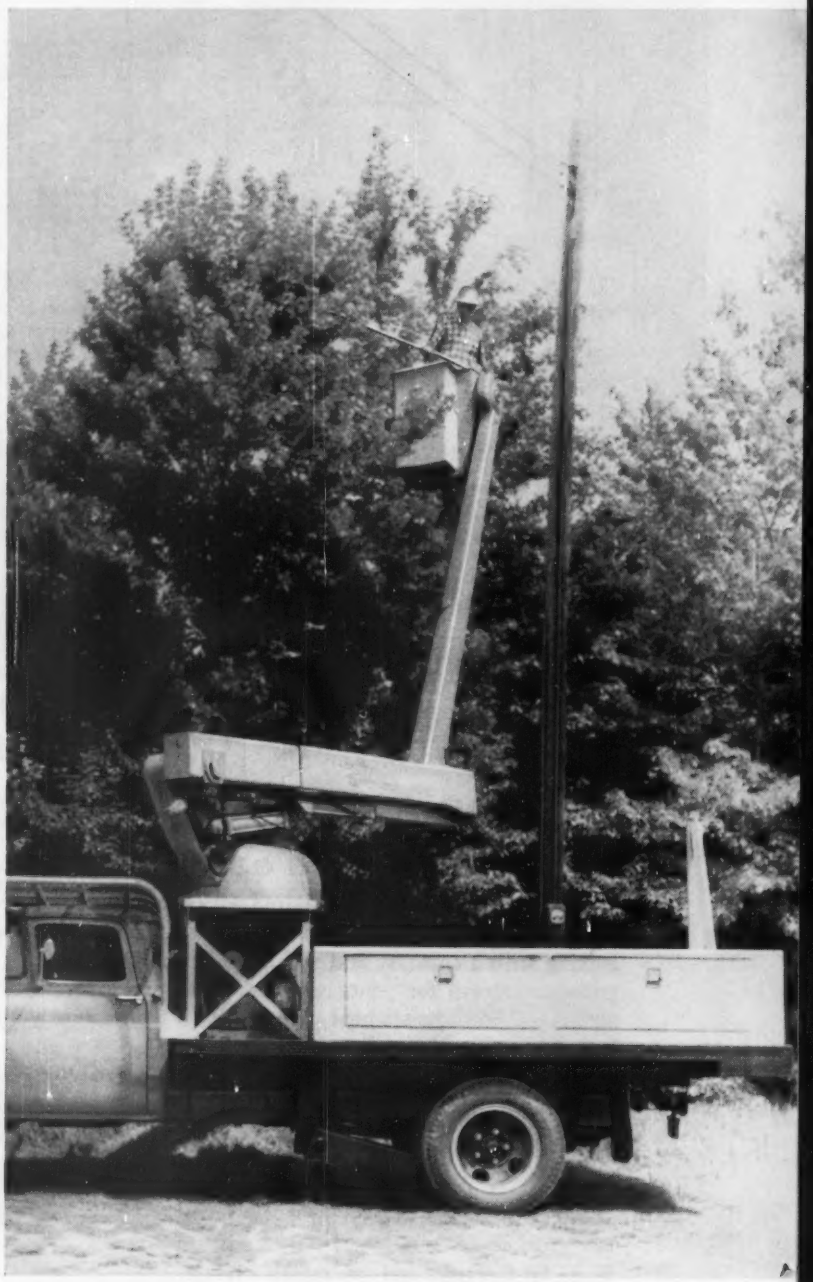
ONAN SEPARATE GENERATORS



For applications where driving power may be taken from the main engine, Onan supplies separate heavy duty generators.

CALL BOB WESTRUM at Onan. He's an expert in solving power plant problems for Original Equipment Manufacturers. Minneapolis, FEderal 2-1155. Or write for complete information on Onan Electric Plants, Generators, other Onan O.E.M. products including Separate Engines and Engine-Driven Compressors.

Electric problems? builder of



HIGH-FLYING CROW'S NEST is powered by a 3.5 KW Onan Electric Plant . . . trusted throughout the world as a reliable, independent source of electricity. Do you have a similar electric problem? Let Onan help you solve it.

Let Onan, world's leading generator sets, help you!

ICE CREAM STORE ON WHEELS! Wherever it goes, this Onan-electrified van has plenty of power for freezers, lights, fans, even the hot fudge heater. A 10 KW Onan does it all.

ALL THE COMFORTS of modern electrical living aboard crafts like these, thanks to Onan Marine Electric Plants. Put an Onan Plant in *your* equipment on the move.

PERFORMANCE CERTIFIED
We certify that when properly installed and operated this Onan electric plant will deliver the full power and the voltage and frequency regulation promised by its nameplate and published specifications. This plant has undergone several hours of running-in and testing under realistic load conditions, in accordance with procedures certified by an independent testing laboratory.
D. W. ONAN & SONS INC.
Minneapolis 14, Minnesota
Onan
WORLD'S LEADING BUILDER OF ELECTRIC POWER PLANTS

POPULAR CW SERIES. This Onan powerhouse—available in 7.5 and 10 KW—features highly efficient Vacu-Flo air cooling. Weighs hundreds of pounds less than comparable water-cooled plants.

D. W. ONAN & SONS INC.
2916 UNIVERSITY AVE. S. E., MINNEAPOLIS 14, MINN.

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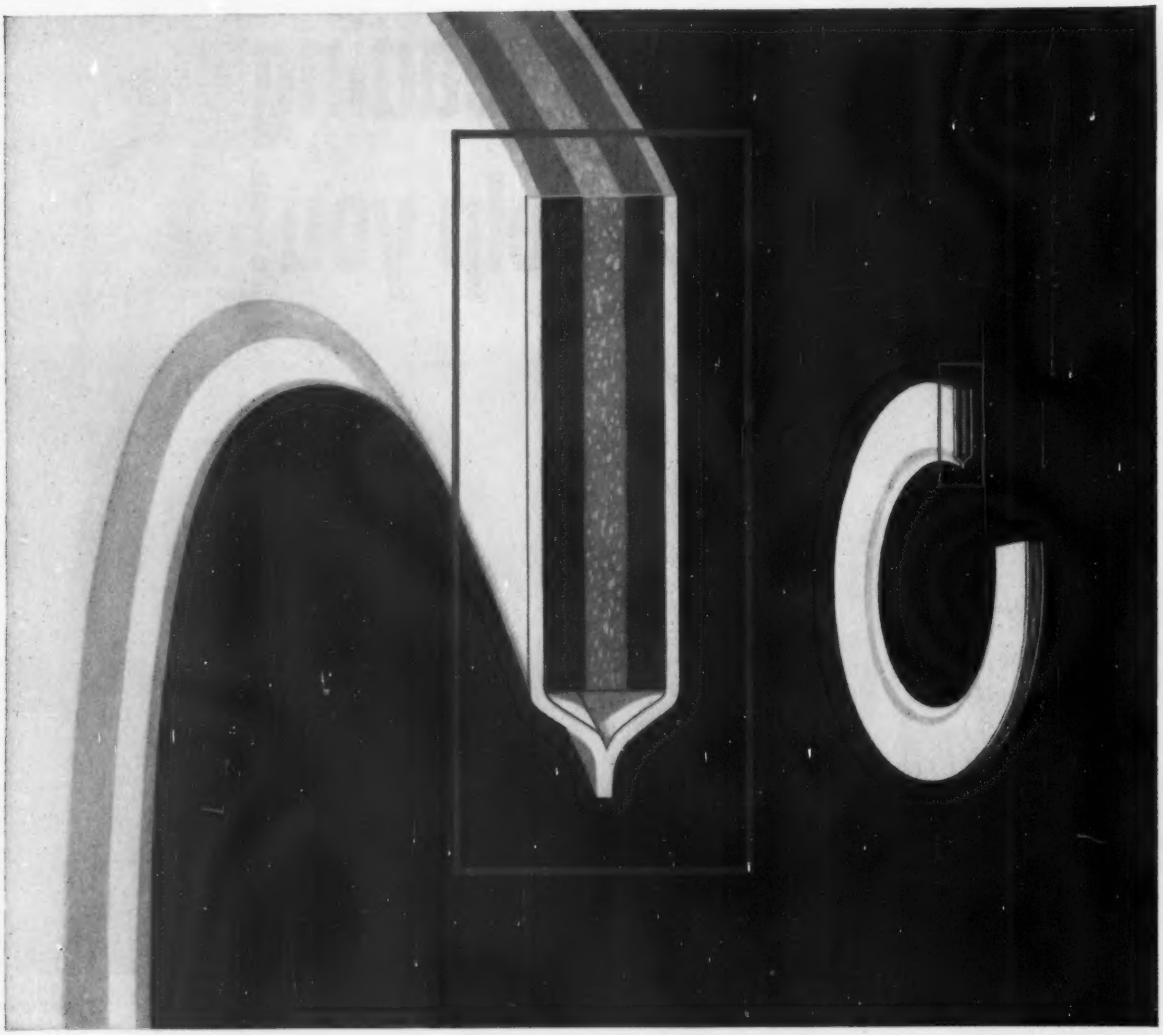

Rely on the gaskets especially designed to handle corrosives, even in glass-lined equipment!

J-M CHEMPAC® GASKETS COMBINE ASBESTOS AND TEFLON FOR LONGER SERVICE PER DOLLAR INVESTED

Here's the gasket that can scoff at active chemicals and solvents. That's because the envelope-type design

combines the protection of both compressed asbestos filler and Du Pont Teflon.

A center core of compressed Chrysotile Asbestos is sandwiched between two layers of felted Blue Asbestos. These three asbestos layers provide longer life . . . outstanding corrosion and heat resistance . . . and the "cushion" effect so desirable in glass-lined equipment. A split or welded envelope of electrical-grade Teflon is then added for even greater corrosion resistance.

Chempac Gaskets are soft, conformable and effect a seal at low bolting. Available in pipe sizes from ⅛" to 12" as standard. Other J-M envelope-type gaskets are also available in various sizes and with special fillers for specific requirements.

It will pay you to solve your corrosive sealing problems with Chempac Gaskets—*especially designed* for that purpose. You can rely on them to give you the most effective sealing . . . and longest, most economical service per dollar invested. See your J-M Distributor. Or write to Johns-Manville, Box 14, New York 16, N. Y. In Canada: Port Credit, Ont. Ask for Chempac Book, PK-124 A.

JOHNS-MANVILLE

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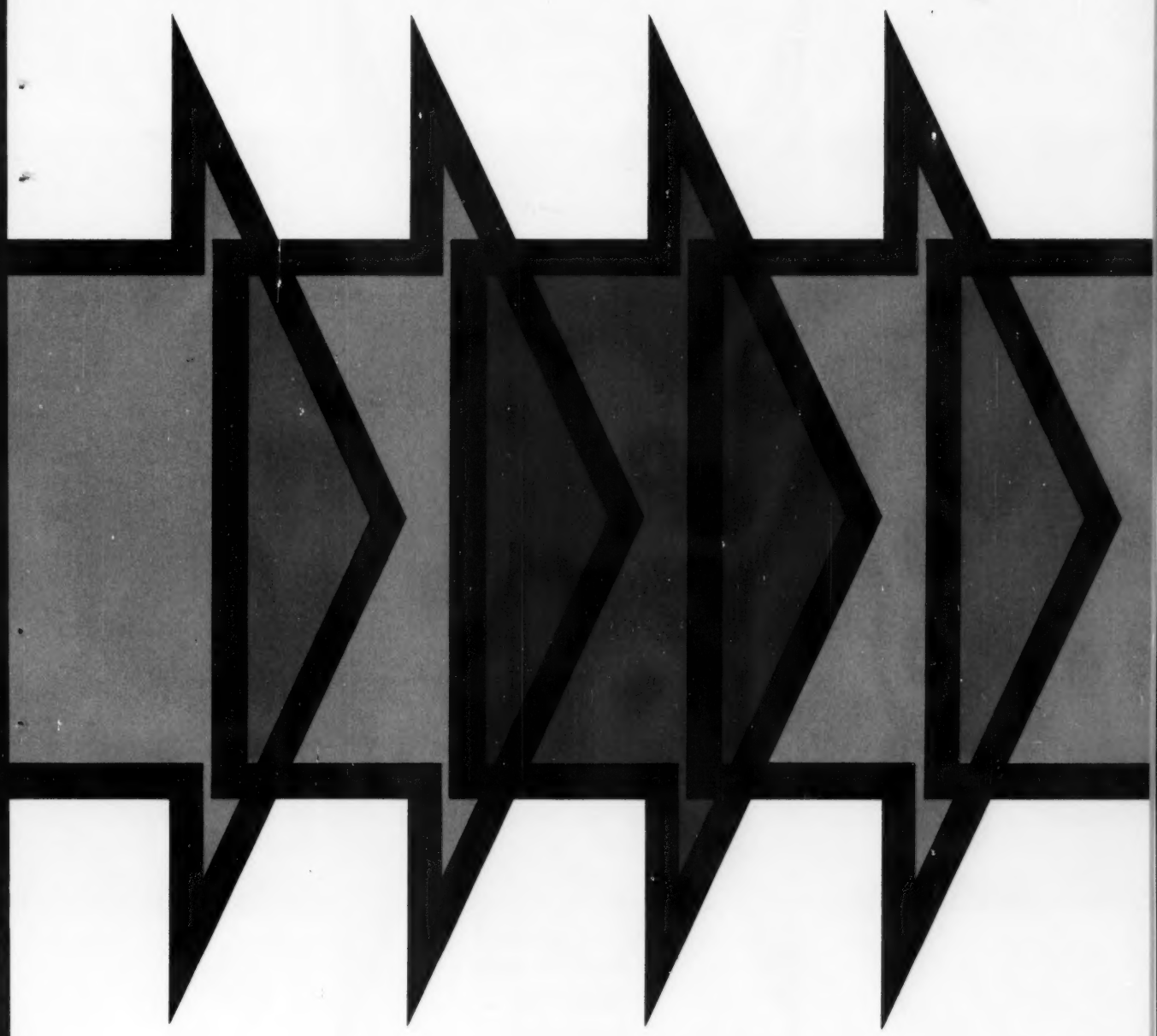


FROM GREAT LAKES STEEL

15 X-A-R 30

ABRASION RESISTANT STEELS

TWO NEW STEELS—HARDER FOR HARDER JOBS

X-A-R

ABRASION RESISTANT STEELS

HARD ENOUGH AND TOUGH ENOUGH TO LAST

Is abrasion your constant enemy? If your equipment meets materials as they're scooped, shoved, slid, pushed, dragged or dumped, does it face the recurring threat of downtime for repairs or replacement? To eliminate such maintenance headaches, Great Lakes Steel has developed two tougher, harder alloy steels—X-A-R 15 and X-A-R 30. They're supplied in hardnesses from 360 to 400 BHN (or, by agreement, in a range of hardness between 265 and 500 Brinell). And they're especially effective and economical in those critical bear-the-brunt areas of the equipment where wear is worst—liners, teeth, bars, blades and plates, for example. *Under conditions that commonly wear out equipment in a hurry, X-A-R abrasion-resistant steels outwear any other type of steel.*

Great Lakes Steel is a division of

WHERE MATERIALS COLLIDE WITH EQUIPMENT

Chemical composition alone is not the secret of low carbon X-A-R steels; their balanced combination of uniformity, high strength, hardness and toughness is the result of close control during heat-treating, quenching and tempering. This makes them more workable, too. Under normal welding and fabricating conditions use X-A-R 30. For *extremely* difficult problems, such as welding under cold conditions or extensive flame cutting, choose X-A-R 15.

X-A-R abrasion resistant steels are immediately available in ⅛″ to 1″ thicknesses, widths up to 72″ and lengths up to 35′. For technical information and supply sources, see next page.

X-A-R

A PRODUCT OF

GREAT LAKES STEEL

Detroit 29, Michigan

NATIONAL STEEL CORPORATION

15 X-A-R 30

TECHNICAL INFORMATION

CHEMICAL COMPOSITION

X-A-R steels are furnished at two specified carbon ranges. These are 14 to 20 carbon for X-A-R 15 and 25 to 30 carbon for X-A-R 30. The balance of the typical composition is:

Manganese	.80%	Chromium	.65
Phosphorous	.020	Molybdenum	.20
Sulphur	.028	Zirconium	.06
Silicon	.60		

TYPICAL MECHANICAL PROPERTIES

	At Brinell Hardnesses of: 363	400
Tensile Strength, psi	180,000	200,000
Yield Strength, psi	165,000	180,000
% Elongation in 2"*	17	16
% Reduction in Area*	56	55
Charpy V Impact at —75°F.	12 (Ft. Lbs.)	7

*Based on standard .505" specimen

ENGINEERING DATA

Resistance to Atmospheric Corrosion (Rural, Marine, and Industrial Environments)	3-5 times copper-bearing or carbon constructional steel
Compressive Yield Strength, psi	Approx. equal to Tensile Yield Strength
Ultimate Shearing Strength, psi	Approx. equal to Tensile Yield Strength
Modulus of Elasticity, psi	29/30,000,000
Endurance Limit (rotating beam)	60% of Tensile Strength
Coefficient of Expansion per °F.	70°F. to 200°F.—.0000062

FABRICATION

Cold Bend Test: Moderate bending can be performed within the usual range of hardnesses. For free bending, it is recommended that a mandrel be used not less than ten times the thickness of the metal through an angle of 90°.

Welding: Low hydrogen electrodes are recommended for welding X-A-R steels. The grade of electrode used is dependent on the strength requirement of the weldment.

Burning: X-A-R steels can be flame cut without pre-heating or stress relieving after cutting.

COMPLETE METALLURGICAL SERVICE

In addition to the information given in this folder, there is a great deal of detailed data available to steel users covering all characteristics of X-A-R steels. Furthermore, a thoroughly competent metallurgical service organization is available to work with you on any application problem you may have.

X-A-R STEELS ARE AVAILABLE AT THESE STEEL SERVICE CENTERS

BENEDICT-MILLER
Lyndhurst, New Jersey

JOSEPH DEMSEY COMPANY
Cleveland, Ohio

DUCOMMUN METALS & SUPPLY COMPANY
Los Angeles, California

INTERSTATE STEEL COMPANY
Evanston, Illinois

LOCKHART IRON & STEEL COMPANY
Pittsburgh, Pennsylvania

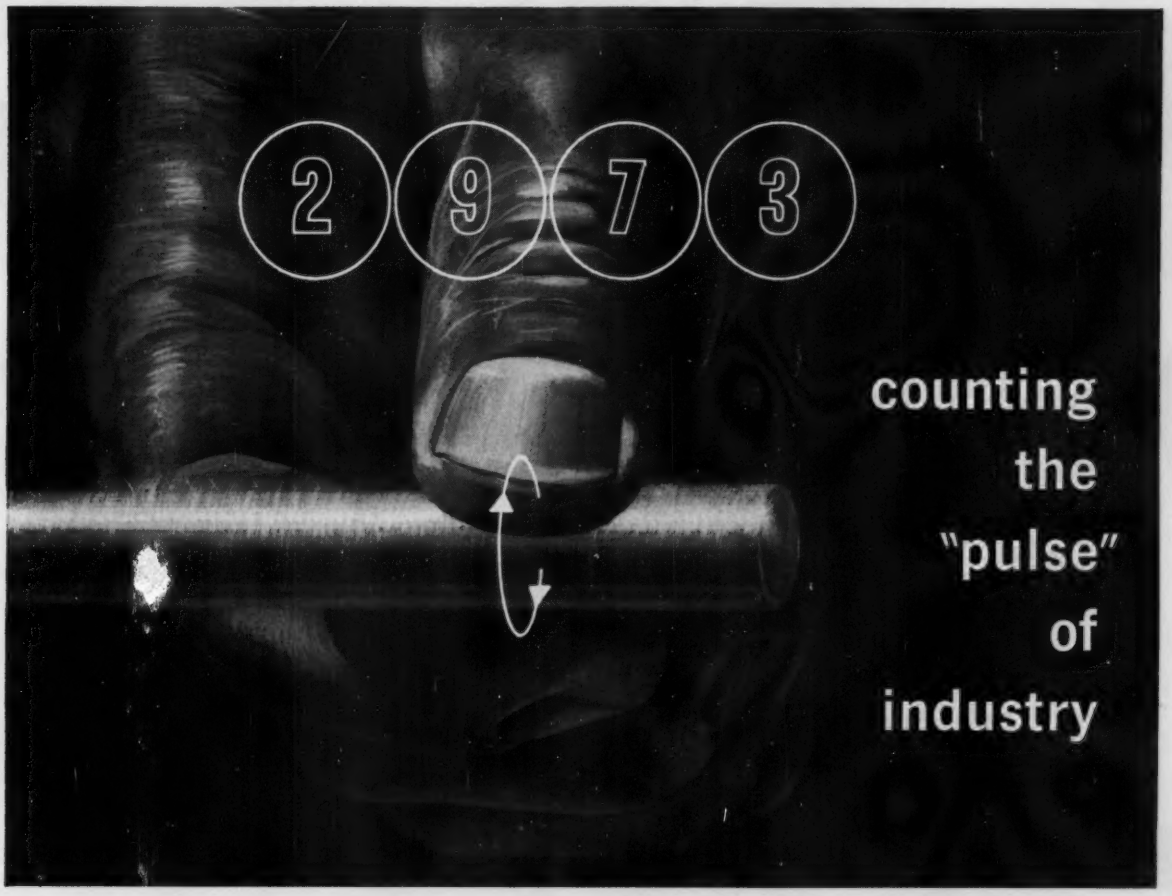
MARSH STEEL & ALUMINUM COMPANY
Kansas City, Missouri

O'NEAL STEEL, INCORPORATED
Birmingham, Alabama

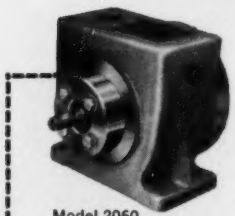
SALT LAKE HARDWARE COMPANY
Salt Lake City, Utah

A. C. LESLIE & COMPANY, LIMITED
Montreal, Canada

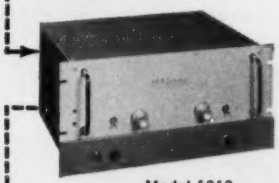
15 X-A-R 30
ABRASION RESISTANT STEELS



...through MERIAM·ILS electronic speed indicating systems



Model 2060
Explosion-proof
Tachometer Pickup.
U. L. Approved.



Model 1313
Remote Electronic
Frequency Counter

Model 1313P
Digital Readout

MERIAM engineers are dedicated to the design and manufacture of speed indicating instruments. Their achievements already include outstanding accomplishments in the fields of automation, jet engine development, automobile components, conveyor control, pumps and electric motors. This is why we say . . . specify a Meriam matched system of pulse pickups, counters and digital readouts from a wide variety of units which have been developed to meet the needs of virtually all applications. Meriam instruments are constructed for heavy-duty industrial use and, if required are available with explosion-proof housings for applications in hazardous areas.

THE **MERIAM** INSTRUMENT CO.

ILS ELECTRONIC DIVISION

Send for detailed specification charts for Meriam Electronic Speed Indicating Systems.

9000-MI

The Meriam Instrument Co.
I L S Electronic Division
10901 Madison Avenue, Cleveland 2, Ohio

Please send Bulletin No. 2000

Name _____ Title _____

Company _____

Street _____

City _____ Zone _____ State _____

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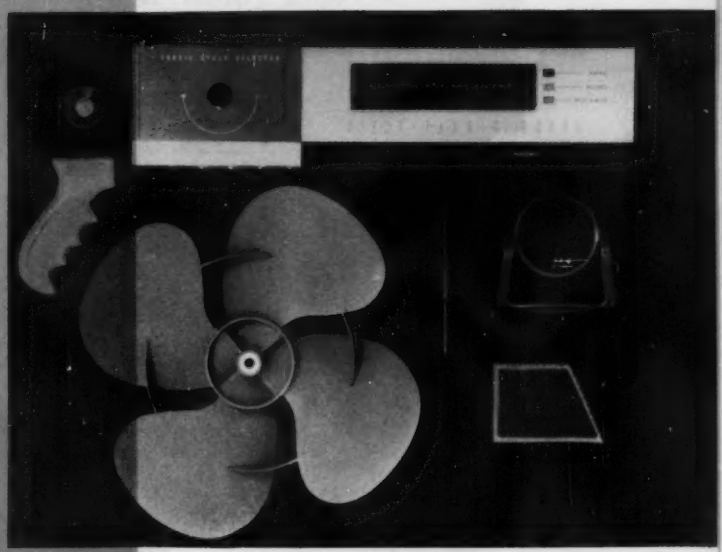
Circle 432 on Page 19

How the custom molder can help bring your product idea to life

The custom molder is well-known as a mass producer of molded plastics parts and products. But he is much more. Most helpful to the designer, the custom molder knows the design limits of the different plastics. He can recommend the best formulation for the job. He can also engineer the design to capitalize on the inherent advantages of plastics materials and the efficiencies of plastics manufacturing. His toolmakers build the master molds to the closest tolerances. His productive facilities can turn out plastics parts with unusually consistent quality, at rates to meet the tightest schedules and budgets.

Monsanto keeps the custom molder supplied with molding formulations of Monsanto Polyethylene, Lustrex® Styrene, and Opalon® Vinyl, specially developed and constantly perfected to meet a wide range of design requirements.

Which molding compounds to consider? Use the Plastics Properties Calculator, an easy-to-read slide rule that provides comparative property data on the many different plastics molding materials. For your free calculator, write to Monsanto Chemical Company, Plastics Division, Room 732, Springfield 2, Mass.



MONSANTO PACE-SETTER IN **PLASTICS**

Monsanto

Circle 433 on Page 19

SURE CURE FOR "LEANONERITIS"*

Several years ago, O. Scott Reid, owner of the Reid Valve Company, invented and produced a plastic valve. But the unit couldn't take the abuse of leaner-on-ers. The plastic wasn't strong enough.

As improved plastics became available, Reid put them through a series of tests to find a stronger material. He chose SUPER DYLAN® high-density polyethylene because it provided the toughness, stability, and durability required. And it gave him low permeability and high resistance to chemicals.

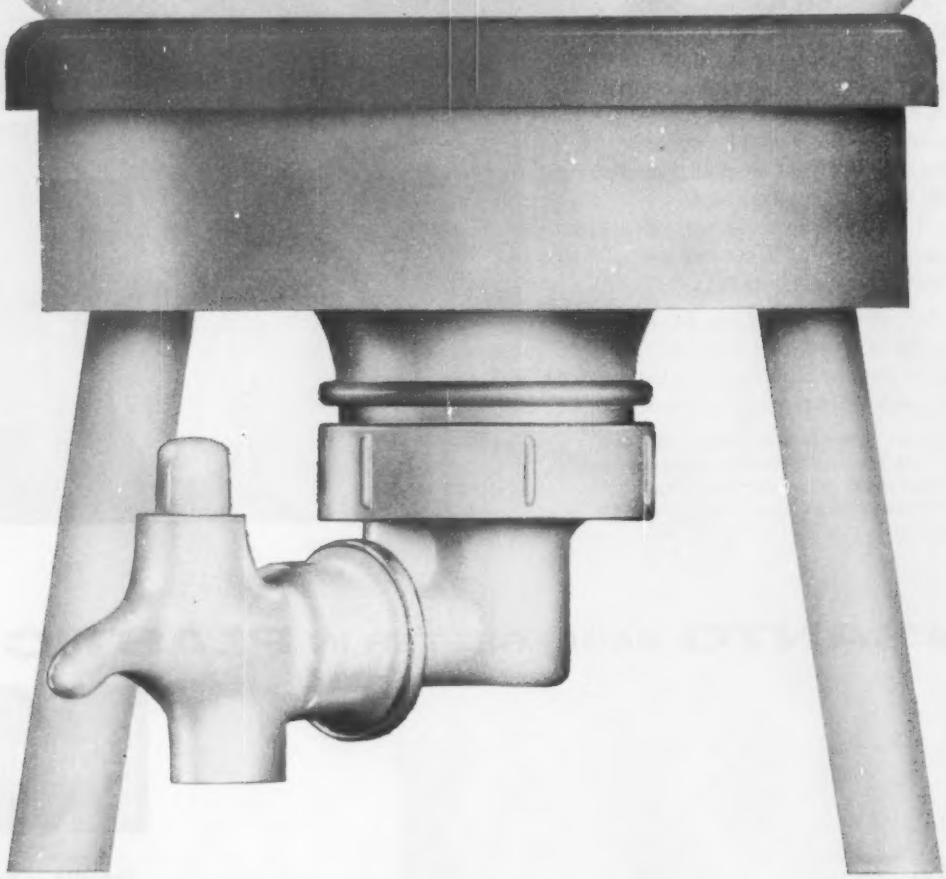
Now, the Reid Valve Company of La Canada, California manufactures a rigid, non-corrosive, long-wearing faucet . . . one that can stand abuse. These SUPER DYLAN valves are smooth, glossy, easily cleanable, and they won't drip.

SUPER DYLAN can be molded in a wide range of sizes, shapes, and colors suited for the particular needs of your product. For more information on SUPER DYLAN, write to Koppers Company, Inc., Plastics Division, Dept. RV90, Pittsburgh 19, Pennsylvania.

DYLITE® *expandable polystyrene,* DYLAN® *polyethylene, and* DYLENE® *polystyrene are other fine plastics produced by Koppers Company, Inc.*

**Tendency to lean on faucets.*

KOPPERS PLASTICS KOPPERS



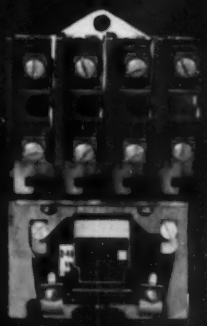
Circle 434 on Page 19

Circle 435 on Page 19→

compare

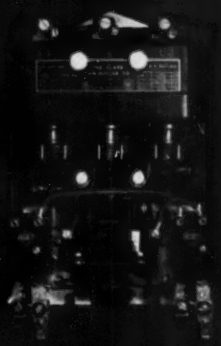
CLARK CONTROLS...

NEW Push Button Line



"PM" Relay Line...

with new "Color-Selective" Conversion Kits



Type "CY" Starters... the standard for longer operating life

SEE FOR YOURSELF WHY THEY GIVE YOU MORE THAN ANY CONTROLS YOU CAN NAME

The **CLARK CONTROLLER** *Company*

compare

see for yourself why...

NEW Clark Push Buttons with exclusive wipe action contacts give you more

WIPING CONTACTS—a Clark Controller exclusive—assures minimum contact resistance at all times. As contacts close, unique Clark design creates a sliding action that wipes faces clean of dust and oil.

DUAL COLOR-CODING—buttons and ferrules—in many separate colors, makes possible advantageous color-coding of stations both by individual operating function and group function.

THREE TYPES OF UNITS offer greater flexibility for any application:

- Type HO Oiltight—Panel or Base Mounted
- Type H NEMA I—Base Mounted
- Type H NEMA I—One Hole (Panel) Mounted

The new Clark Push Button line includes a complete range of buttons, selector switches, pilot lights and push-to-test lights or lighted push buttons—available as individual control units or mounted in enclosures or on flush plates.

compare

see for yourself why...

Clark Type "CY" Starters give you more than any other A-C magnetic starter

Whatever your basis for comparison let your own performance check show you how Clark Type "CY" Starters outperform all other starters—give you more.

DEPENDABILITY? Compare the Clark Type "CY" Starter in the toughest application you can find—then see for yourself how it continues to operate dependably where other starters fail.

LONGER OPERATING LIFE? Make your own comparison life test—then see for yourself how much better a Clark Type "CY" Starter holds up under any operating conditions.

OTHER ADVANTAGES? Your own comparison tests on installation, maintenance, and any other requirements, will let you see for yourself that the Clark Type "CY" Starter gives you more than any other A-C magnetic starter in every area of importance.

Clark Type "CY" Starters are available in many combinations, in sizes 0 thru 4, and in a variety of enclosures and forms to meet every industrial application.

More for your money with

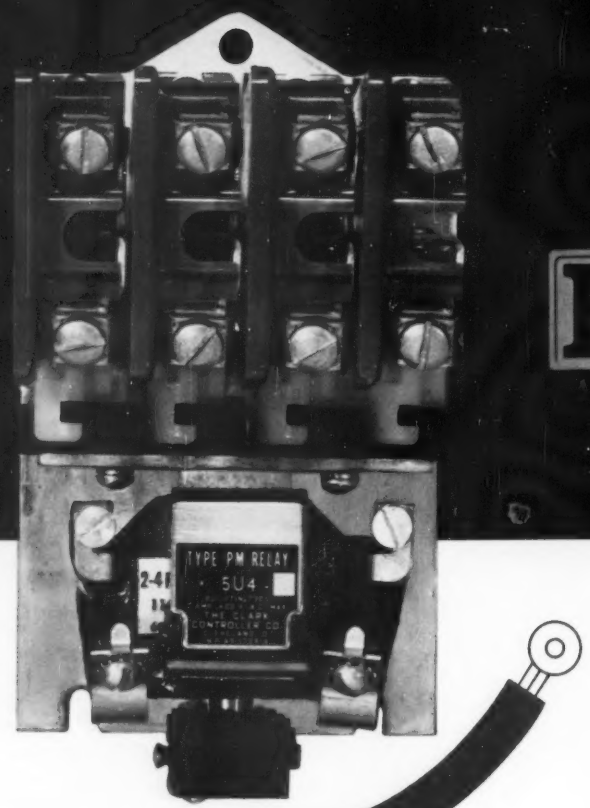
CLARK PUSH BUTTONS

DEMONSTRATION? Ask your local Clark distributor or district sales representative for a demonstration and free literature on the new push button line. Or, write direct to The Clark Controller Company.

More for your money with

CLARK STARTERS

MORE INFORMATION? Your local Clark distributor or district sales representative will be glad to help you set up your own comparison tests. Ask for literature on the complete Clark Type "CY" Starter line, too. Or, write direct to The Clark Controller Company.



compare

see for yourself why...

Color-coded conversion kits help solve any relay circuit problem with building-block simplicity

New color-coding of conversion kits by function now makes it possible for relay users to take even greater advantage of the versatility and flexibility of the complete, integrated line of Clark "PM" Relays.

Basic relays are easily modified on the job with a few simple conversion kits to give you a virtually unlimited number of circuit arrangements on convertible pole, universal pole, latch and time-delay relays.

The "modular construction" of all relays in the Clark "PM" line insures integrated uniformity, compactness and flexibility. Functional alignment in mounting results in neater, more uniform panels and most efficient utilization of valuable space.

More for your money with

CLARK RELAYS

COMPLETE INFORMATION on Clark color-selective conversion kits is available through your local Clark distributor or district sales representative. Or, write direct to The Clark Controller Company.

The
CLARK CONTROLLER *Company*

"Everything Under Control"

Main Plant: *Cleveland 10* • **Western Plant:** *Los Angeles 58*
In Canada: *Canadian Controllers, Limited, Toronto*

INVESTMENT CASTINGS

small
or
large

in any metal--ferrous or non-ferrous, including magnesium
in any quantity--production or prototype

Arwood's casting facilities enable us to cast parts that range from a fraction of an ounce up to 100 pounds. You now have a single source for small and large castings. It's just another good reason for doing business with Arwood.

- Five production plants throughout the country.
- Complete design, tooling and metallurgical research facilities.
- Eighteen years' experience in casting *all* the metals and alloys that can be poured into a mold – including everything from magnesium right through to stainless steel and difficult-to-machine superalloys.
- A time-tested record for reliability in meeting quoted prices and scheduled deliveries.
- Seventy-one trained engineering representatives coast to coast.

So . . . when the specifications call for an investment casting, you'll find that it pays to get a quote from Arwood.

Like to know more about investment casting? Send for our 44-page "Practical Guide to Investment Casting." It's yours for the asking.

Machine the simple . . . cast the complex

A complete service from design through tooling, production and finish machining. Seventy-one engineering representatives from coast to coast.

arwood

ARWOOD CORPORATION • 315 West 44th Street, New York 36, New York

PLANTS IN BROOKLYN, N. Y.; TILTON, N. H.; GROTON, CONN.; LOS ANGELES AND LA VERNE, CALIF.

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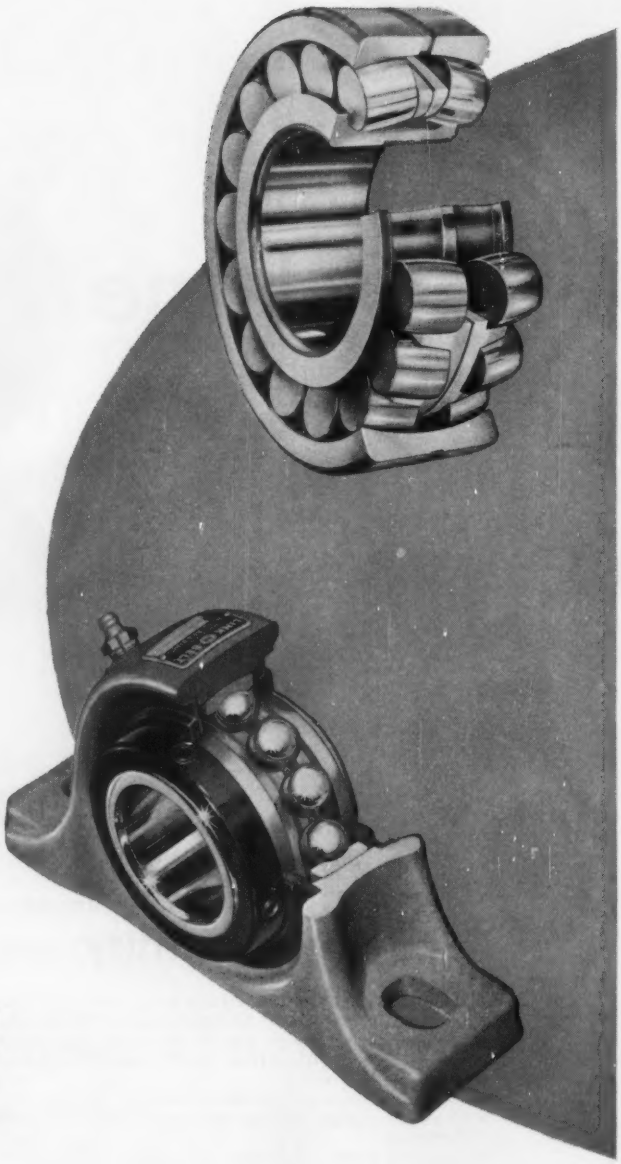
Whatever turn shafts may take...



it's easy to match your needs from LINK-BELT's complete line of self-aligning ball and roller bearings

High speeds, low speeds—light loads, heavy shock loads, there's a Link-Belt bearing to keep every shaft turning continuously and economically.

Link-Belt's line of ball and roller bearings, the most complete in industry, includes spherical roller bearings, pillow blocks, and flanged, flanged cartridge, cartridge and takeup blocks. All have industry's *preferred* bearing features and all have won the reputation of "the designers' choice."

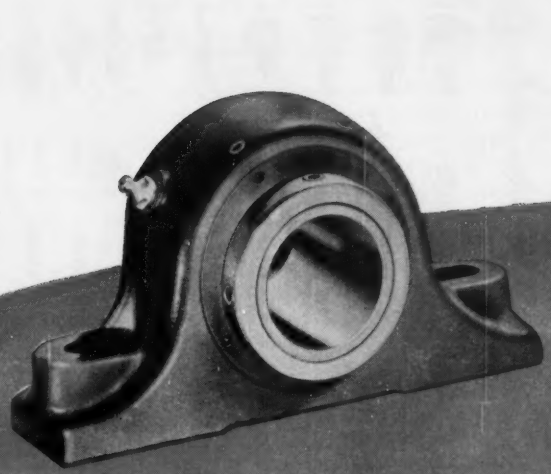
Link-Belt self-aligning ball and roller bearings compensate for inaccuracies in fabrication and assembly of equipment while maintaining full load capacity throughout their long life. Their compactness promotes simplicity of machinery design—their easy mounting reduces installation costs.

Available from local stocks; contact your nearest Link-Belt office. Look under BEARINGS in the yellow pages of your phone book. Ask, too, for Book 2760 and 2550-C containing full information on the complete Link-Belt ball and roller bearing line.

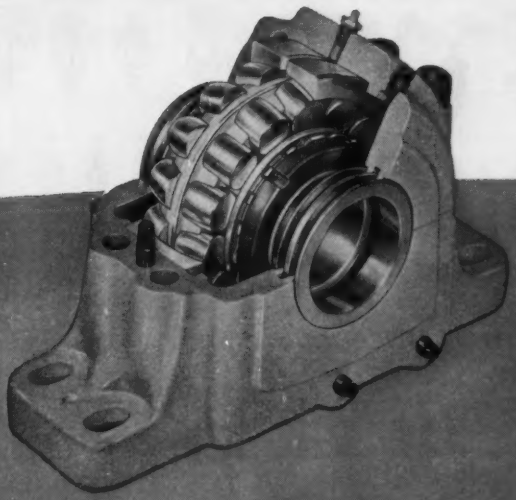
LINK-BELT

SELF-ALIGNING BALL AND ROLLER BEARINGS

LINK-BELT COMPANY: Executive Offices, Prudential Plaza, Chicago 1. To Serve Industry There Are Link-Belt Plants, Warehouses, District Sales Offices and Stock Carrying Distributors in All Principal Cities. Export Office, New York 7; Australia, Marrickville (Sydney) Brazil, Sao Paulo; Canada, Scarboro (Toronto 13); South Africa, Springs. Representatives Throughout the World. 15.413-A



ROLLER BEARINGS WITH SOLID HOUSINGS employ heavy-duty, double-row self-aligning roller bearings. Available with cast iron or cast steel housings. Choice of seals to match operating conditions. Compact, rugged and easy to install. Series 400, for ¾" to 4" shafts.



SPHERICAL ROLLER BEARING PILLOW BLOCKS feature Link-Belt's *new Spherical roller bearings* in sturdy cast iron or super-rugged cast steel housings. Designed for either adapter or direct shaft mounting. Choice of rugged steel multi-labyrinth or Dacron contact seals. For shafts from 1 7/16" to 10½".

NEW SPHERICAL ROLLER BEARINGS combine all the best features of modern bearing design: precision-machined, centrifugally cast bronze retainers; big, highest-capacity rollers; high, heavy inner race flanges. Bearing bores from 40 mm (1.5748") to 220 mm (8.6614").

ALSO AVAILABLE FROM LINK-BELT'S COMPLETE BALL AND ROLLER BEARING LINE

FLANGED BLOCKS

CARTRIDGE BLOCKS

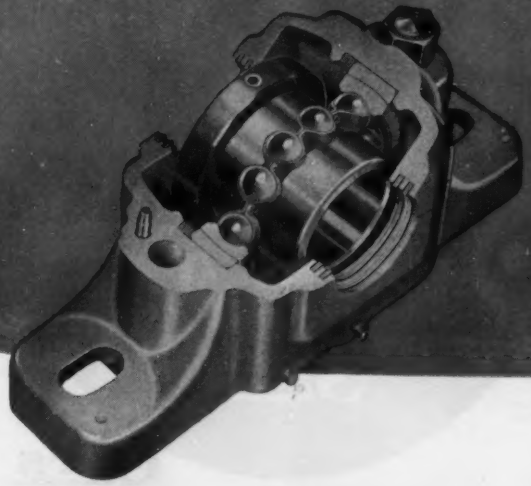
FLANGED CARTRIDGE BLOCKS

TAKEUP BLOCKS

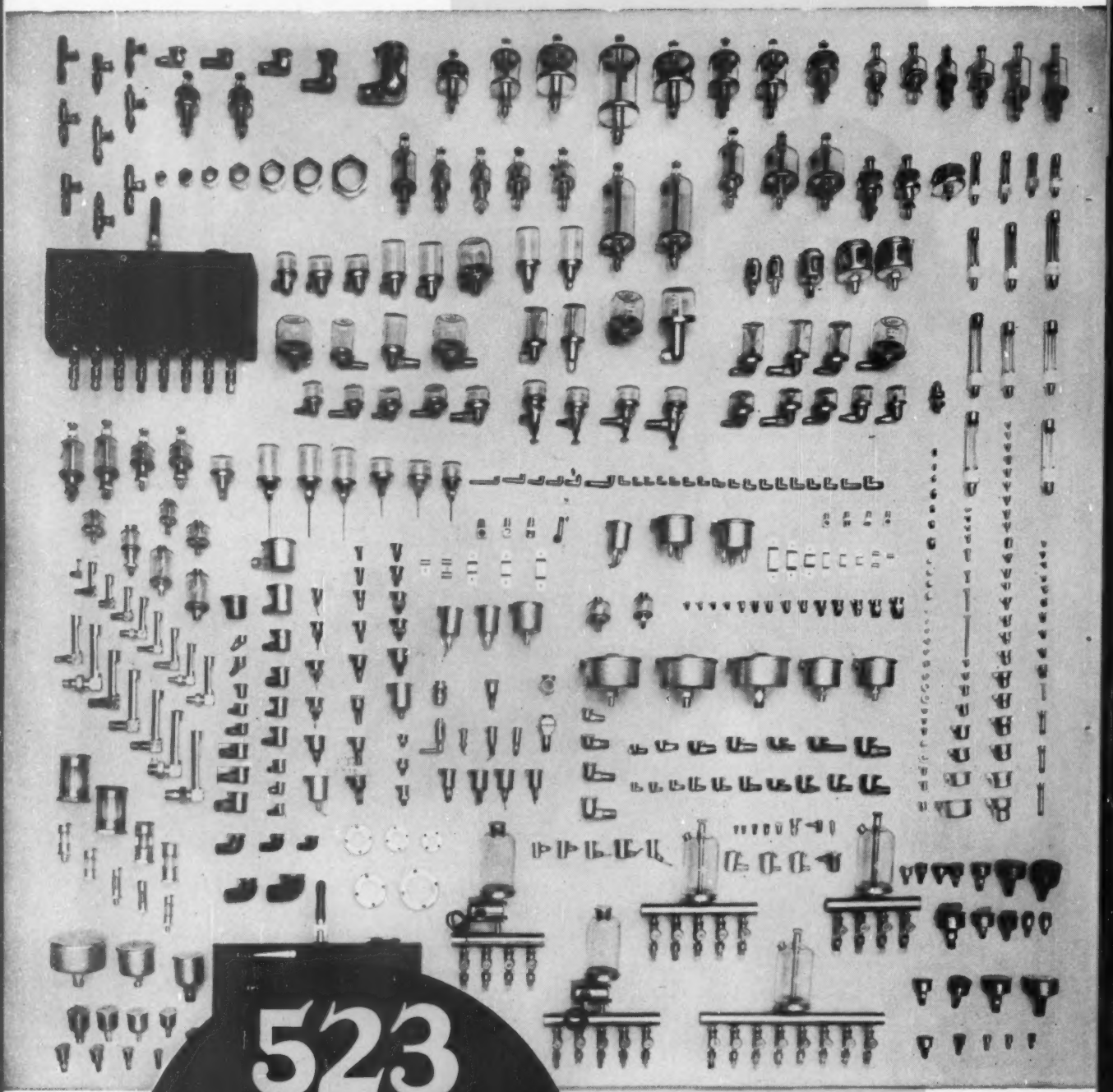
BALL BEARINGS WITH SOLID HOUSINGS feature self-aligning, single row, deep groove ball bearings. Precision balls operate on honed raceways assuring smooth, quiet operation. Spring locking collars simplify installation . . . lock bearings securely to shaft. One piece housings are compact, require minimum support space. Series 200 and 300, for ½" to 4" shafts.

BALL BEARINGS WITH PRESSED STEEL HOUSINGS come completely assembled, ready to install. These low cost, dependable pillow blocks have self-aligning bearings to compensate for mounting inaccuracies. Spring locking collars assure tight fit on shafts. Lubricated for life, these bearings require no maintenance. Series JPS-200, for ½" to 1 7/16" shafts.

BALL BEARINGS WITH TWO-PIECE HOUSINGS provide ease of installation, simplify bearing and lubricant inspection. Large reservoir for oil or grease makes them ideal for high speed applications. Bearings are self-aligning to compensate for shaft misalignments. Series 200 and 300 for 1⅛" to 3 15/16" shafts.



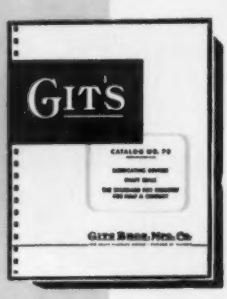
Circle 437 on Page 19



523 GITS OILERS AND GAUGES READY TO SHIP

Largest selection available anywhere. You save time and money, because the one you want is always right in stock. Send for complete Catalog.

Specialists in Lubricating Devices and Shaft Seals for Almost Half-A-Century



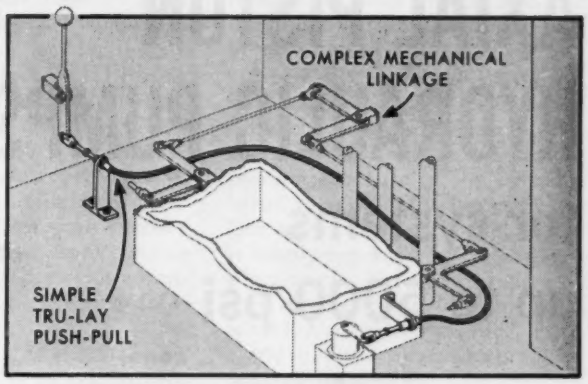
GITS BROS. MFG. CO.

1868C S. Kilbourn Ave., Chicago 23, Ill.

Circle 438 on Page 19

TRU-LAY *PUSH-PULL* CONTROLS PROVIDE ACCURATE, DEPENDABLE REMOTE CONTROL FOR HUNDREDS OF PRODUCTS

• If your products involve remote control—electrical, hydraulic, pneumatic or direct—TRU-LAY PUSH-PULL FLEXIBLE CONTROLS can help solve your design problems. They provide positive remote control over long or short distances—up to 150 feet from the control point. Because they operate while flexing, they can snake around obstructions. They will not buckle. They are ruggedly constructed, easily installed and operated, sealed against dirt and moisture, and will handle jobs with as much as 1,000 lbs. input. PUSH-PULL CONTROLS are simple, have but one moving part, are noiseless, and give a lifetime of accuracy. Mechanical linkages, on the other hand, are complex. Unlike PUSH-PULL CONTROLS, they are made of many parts, wear at many points, and produce increased backlash, lost accuracy, and vibration rattles.



Sizes and Operating Heads to Fit Your Design

Control Dimension	Minimum Recommended Radius in Inches	Maximum Input Load in Pounds (Dependent on Travel)
3/32"	2	30
1/8"	3	65-125
3/16"	5	115-175
1/4"	6	300-600
5/16"	8	700-1,000

Heavy Duty • For use where rugged duty prevails, but where operation must be smooth and accurate. Meets all requirements for dependability and life.

Light Duty • Gives smooth, accurate and dependable performance at low cost. Available with your choice of several types of knobs.

Selective Friction • Amount of friction can be changed to meet individual requirements of the operator or application. Friction constant at any setting.

Position Lock • A slight turn of the T-type handle locks the control in any position. Available in two sizes for light and heavy-duty applications.

Micro Control • Push or pull the knob for instantaneous response, then rotate knob for vernier adjustment. Built for smooth, efficient operation on any job.

PUSH-PULL DATA FILE shows how to simplify, improve design

PUSH-PULL CONTROLS are solid as a rod and flexible as a wire rope. They're factory-lubricated for life, unaffected by temperature extremes, and can be adapted to practically any application. For complete details on how you can use them, write for the PUSH-PULL DATA FILE. It contains 7 engineering Bulletins which describe in detail the operation of PUSH-PULL CONTROLS, their applications, features and advantages. Our engineers will be glad to help you make TRU-LAY PUSH-PULL CONTROLS a part of your product.

PUSH-PULL CONTROLS

Automotive and Aircraft Division • American Chain & Cable Company, Inc.

601-A Stephenson Bldg., Detroit 2

6800-A East Acco Street, Los Angeles 22 • 929-A Connecticut Ave., Bridgeport 2, Conn.

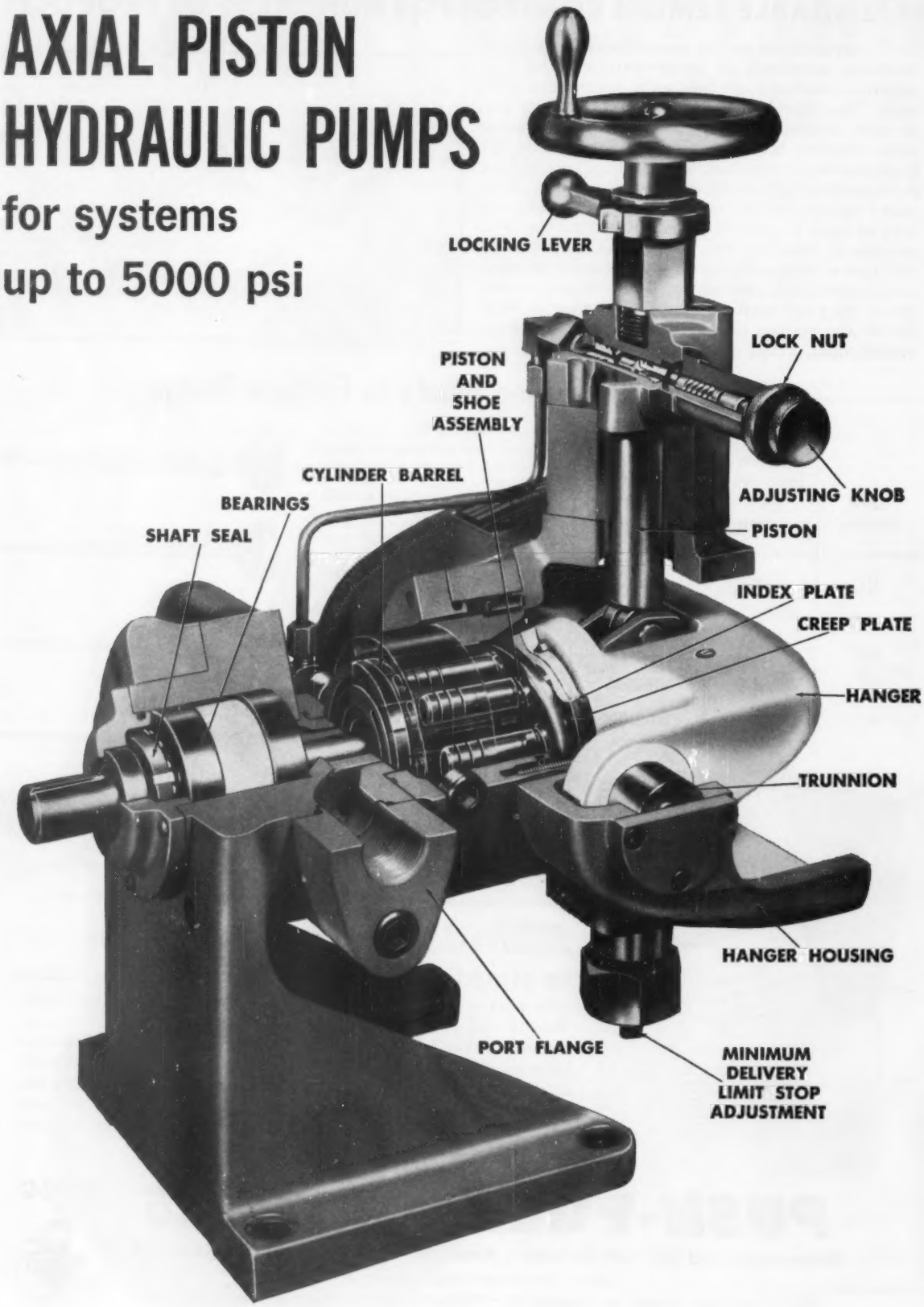
ACCO

Circle 439 on Page 19

Design of variable volume

AXIAL PISTON HYDRAULIC PUMPS

for systems up to 5000 psi



By: Ellis H. Born

Director of Sales-Engineering
Denison Engineering Division
American Brake Shoe Co.
Columbus, Ohio

With today's ever-increasing requirements in the transmission of higher horsepower, the designer must look to hydraulic components that will give the greatest transmission efficiency with the lowest possible cost and the smallest possible package. With smaller, lighter, more powerful equipment—operating pressures of 2000, 3000 and 5000 psi are becoming commonplace. To meet the needs of higher pressures with a high degree of reliability, axial piston pumps and motors of proper design should be considered.

For 5000 psi requirements, the axial piston pump (illustrated) is a logical choice. It operates on the principle of a series of pistons in a common barrel that progressively draw oil into the barrel on the suction stroke and force oil from the barrel into the line on the discharge stroke.

With this simple axial piston design, direct and unrestricted flow into the pumping assembly is possible, eliminating the need for the large flow areas used and the moving seals which, in turn, eliminates maintenance. Direct flow path further insures good suction characteristics —a highly desirable operating advantage for obtaining efficient hydraulic performance.

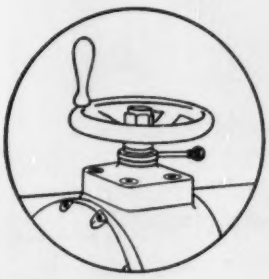
The port plate of the Denison pump is designed as an axial hydrostatic bearing which balances out the thrust of the cylinder barrel, leaving only sufficient force to create a positive seal contact between the cylinder port plate and the cylinder barrel. Because of reduced thrust, wear on mating surfaces is decreased and pump life is greatly extended at all pressures up to 5000 psi.

Where variable volume is required, it is logically desirable (for efficiency, simplicity and low maintenance) to eliminate the need for varying the position or angle of the cylinder barrel to regulate volume. In the Denison axial piston pump, output is simply regulated by varying cam plate angle. Zero to full flow or flow reversal is regulated by handwheel, hydraulic cylinder, stem, electric motor, compensator or electrohydraulically.

In the Denison design, the line of action of the combined radial load of all pistons is through the roller bearing supporting the cylinder barrel. The use of a large bearing provides non-deflecting support for these radial forces. As a result, unbalanced or twisting offset that would tend to unseat the cylinder barrel from the port plate is eliminated. A continuous, effective sealing action of the barrel against the port plate is maintained to promote high pumping efficiency.

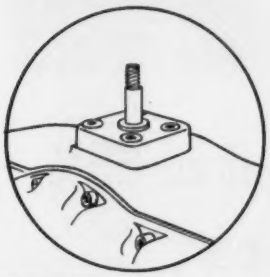
Piston and shoe assembly design also reduces by one-half the number of ball and socket couplings found in other types of axial piston pump construction. The shoes hydraulically balance out all piston thrust, eliminating need for thrust bearings.

Data and specifications on 5000 psi pumps, motors and controls are available from your Denison representative—located in principal cities—to assist you in developing hydraulic systems for maximum efficiency and economy.

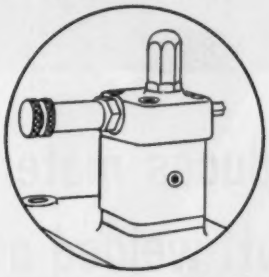


HANDWHEEL CONTROL
...with locking device for accurate manual pump volume regulation.

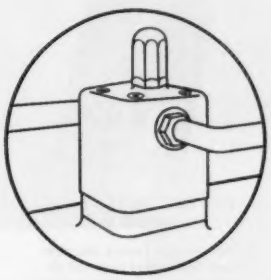
ELECTRIC MOTOR CONTROL
...adjusts pump volume to desired level. Integral brake in gear-head motor eliminates over-travel.



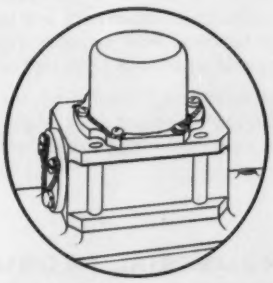
STEM CONTROL
...provides mechanical linkage to the driven equipment.



PRESSURE COMPENSATOR CONTROL
...affords automatic regulation of pump volume to meet preset pressure demands.



HYDRAULIC CYLINDER CONTROL
...similar to stem control, except volume is hydraulically regulated.



ELECTRO-HYDRAULIC CONTROL
...utilizes sensitive, system error-detecting unit which energizes hydraulic volume control piston.

NEW CATALOG FOR DESIGNERS AND ENGINEERS

Write for your copy of Bulletin 220—"Hydraulic power to 5000 psi". Includes complete specifications, operating data and applications for Denison's full line of hydraulic pumps, motors and controls.

DENISON ENGINEERING DIVISION
American Brake Shoe Co.
1240 Dublin Road • Columbus 16, Ohio

Circle 440 on Page 19

Extruded section reduces material required 65% on this flash butt-welded missile part

By leaving 2/3 of the titanium required at the mill, dramatic savings were effected on this ram jet engine part used in the Bomarc.

Amweld quoted the job, suggesting a special extruded section shown here, and saved 19.8 lbs. of expensive titanium per ring. The flash butt-welded rings from extruded sections offered additional savings in machining time, since only a small amount of metal had to be removed.

Amweld is equipped to supply flash butt-welded rings and circular products in stainless, titanium, aluminum, as well as a wide variety of corrosion-resistant alloys. If you would like to know more about Amweld's welding, fabricating and machining facilities, phone or write.

GET THE FACTS ABOUT AMWELD

New 20-page catalog describes flash butt-welded rings and circular products manufactured by Amweld. Also booklet entitled, "How Flash Butt-Welded Rings are Made."

AMWELD® INDUSTRIAL PRODUCTS

THE AMERICAN WELDING & MFG. CO. • 130 DIETZ ROAD • WARREN, OHIO

Circle 441 on Page 19

New! STROBOTAC®

...an Advanced Electronic Instrument for Tachometry and Slow Motion Analysis of Machinery and Cyclic Movement.

This Strobotac is a completely new design based on a unique white-light strobotron tube. Much brighter light — 70 times that of its predecessor — combined with extremely short flash duration reveals operating details of machines and processes. Now you can see in detail the operation of cams, gears, pulleys, linkages, and mechanical parts of all kinds — details you've never seen before.

Improved Contrast — new white light, with an intensity of 4.2 million candlepower on the low speed range, produces tremendous improvement in viewing conditions.

Long-Throw Beam — the new Strobotron tube produces a concentrated beam of light which is ideal for penetrating into the heart of complex machinery.

Sharp Flash — (1 to 6 μsec duration) "freezes" motion and shows clearly a degree of detail that was heretofore invisible; practically eliminates blur.

Speed Range Extended Upward — 25,000 rpm direct reading; useful to approximately 50,000 rpm. Lower limit 110 rpm direct reading; lower with external multiplier.

1% Accuracy — permanently assured by panel neon-bulb calibrator; easily checked at a glance.

Pivoting Lamp — rotates 90° in horizontal direction and 180° vertically. Lamp can be aimed at object under investigation while instrument is positioned conveniently for a clear view of calibrated rpm scale.

Easier to Read and to Use — one simplified dial and range switch controls rate of flash; only the scale to be used is illuminated at a time. Direct reading from 110 to 25,000 rpm.

Lighter Weight — just [illegible] pounds, and only ½ size of previous model.

Unique Carrying Case — provides a convenient, adjustable stand; serves as rugged enclosure for instrument in storage or transit.

Type 1531-A STROBOTAC

$260.

Write for more information

GENERAL RADIO COMPANY

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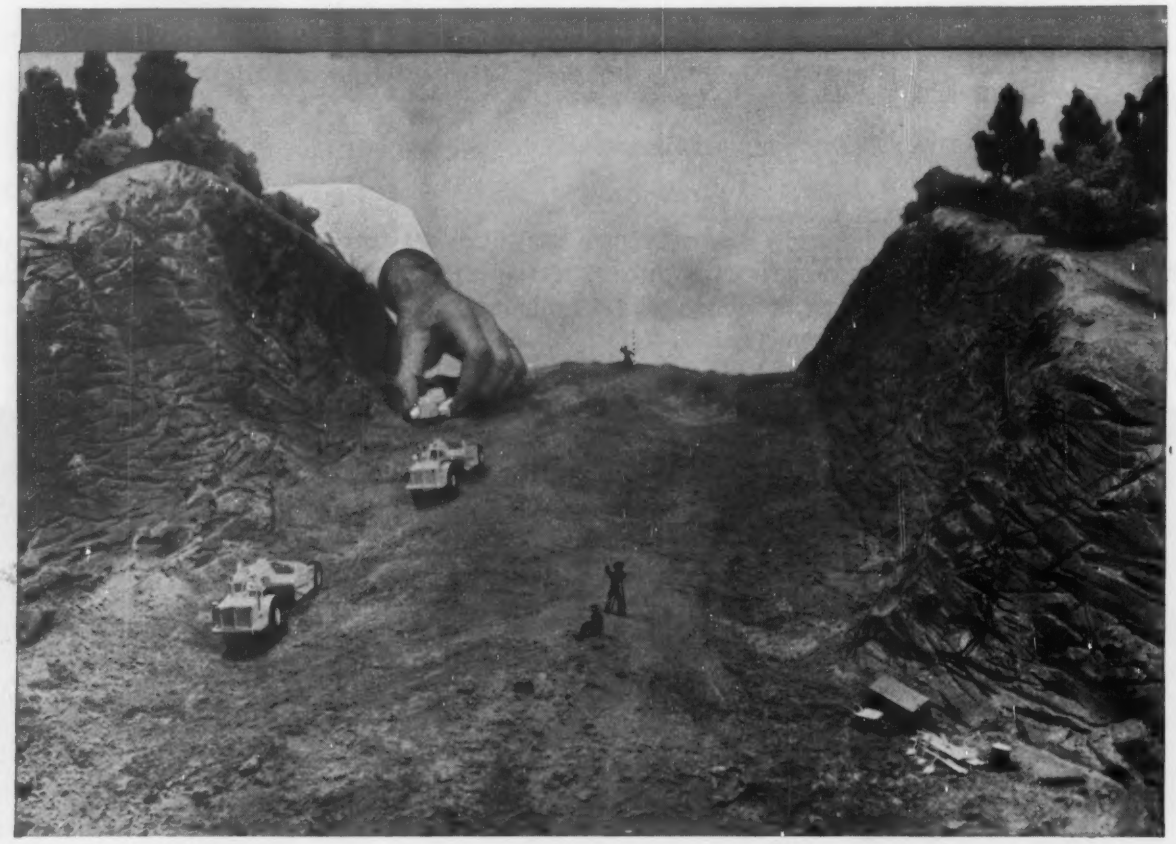
Circle 442 on Page 19



Custom made for rugged service

Big-job earth moving is a slamming, bruising, round-the-clock business that plays hob with construction machinery. Only the best custom-designed equipment can take the brutal punishment.

And only the finest, toughest seamless tubing can come up smiling in this rugged service. Custom quality Ostuco Tubing stands the gaff . . . fills the bill order after order.

If you're now compromising with stock tubing, consider all the advantages of custom quality Ostuco Tubing. Consistently you receive the exact tubing you want—the size, length, grade—with the strength and tolerances you need. For machined parts, you get our recommended rough size guaranteed to clean up.

With all these advantages, custom quality Ostuco Tubing is obtainable in small minimum quantities—as little as a few hundred feet. Contact your nearest Ohio Seamless representative, or the plant at Shelby, Ohio—Birthplace of the Seamless Steel Tube Industry in America.

A-3262A

Scale model illustrated built to 3.5 mm scale.

Complimentary Copy of new Bulletin CS60 "Ostuco Steel Tubing" sent on request.

OSTUCO SHELBY, OHIO

OHIO SEAMLESS TUBE

Division of Copperweld Steel Company • SHELBY, OHIO

Seamless and Electric Resistance Welded Steel Tubing • Fabricating and Forging

SALES OFFICES: Birmingham, Charlotte, Chicago (Oak Park), Cleveland, Dayton, Denver, Detroit (Huntington Woods), Houston, Los Angeles (Lynwood), Miami, Moline, New Orleans (Chalmette), New York, North Kansas City, Philadelphia (Wynnewood), Pittsburgh, Rochester, St. Louis, St. Paul, Salt Lake City, Seattle, Tulsa, Wichita

CANADA: Railway & Power Engr. Corp., Ltd. EXPORT: Copperweld Steel International Company, 225 Broadway, New York 7, New York

Circle 443 on Page 19

Power Take-Offs

for every industrial job

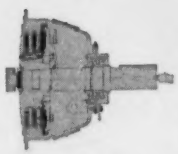
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

Twin Disc Friction and Fluid PTO's — the world's most complete line

STANDARD FRICTION PTO

Easy-to-mount unit consisting of clutch PTO assembly with shaft and bearings in a rigid cast iron housing. Designed for manual operation on all internal combustion engines with standard SAE flywheel housings from No. 6 to No. 00. Triple-plate 14" to 21"; double-plate 11½" to 24"; single-plate 6½" to 24". Twenty models with horsepower capacities to 600 hp and torque capacities to 6730 lbs.-ft.

AIR-OPERATED PTO



A new series combining the convenience of Model PO Air Clutches with the time-tested dependability of Twin Disc Friction PTO's. Ideal for drilling rigs where the operator must work from a remote driller's platform. A touch on a control valve handle engages and disengages the clutch . . . provides "torque without effort." Normally requires only 90 psi air pressure. Capacities to 600 hp. Conversion kits available.

"LIMITED ATTENDANCE" FRICTION PTO

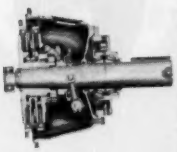
(Illustrated less housing)

A modified version of the standard Twin Disc PTO. Features a new clutch engagement mechanism that virtually eliminates throw-out collar wear, ends daily greasing for good. In oilfield pumping jack service this PTO will quickly pay for itself in labor savings alone because it needs greasing only twice a year. Available in 10", 11", 14", and 18" sizes. Conversion kits for older PTO's also available.

FLUID PTO (Model HU)

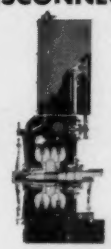
Used on constant-speed, constant-torque drives where efficiency of 95% or better is desired. Consists of a fluid coupling combined with a cast bell housing, bearings and output shaft. In oilfield pumping installations, Model HU improves engine operation by reducing variation in engine rpm per stroke by as much as 50%. Also cuts engine vacuum variation for lower BMEP. Sizes: 14.5, 17.5 and 21.

NEW "HIGH-ENERGY, HIGH-SPEED" PTO



A recent Twin Disc development for engines developing 300 to 500 hp at speeds up to 3380 rpm. Designated Model IBF-214P, it has a unique ventilated center plate that permits air flow to dissipate excess heat. An amazing ability to withstand high-energy loads makes this PTO well suited to applications where equipment is subject to heavy starting loads. Tapered roller bearing is continuously lubricated with oil. Improved throw-out collar design permits extending greasing periods up to six months.

DISCONNECTING FLUID PTO (Model HUD)



Disconnects power source from driven equipment to reduce impact shocks 70% or more. Eliminates "engine fighting" to assure balanced distribution on compounds. Life of chains, clutches and other running parts is almost doubled. Isolation of torsional vibrations and elimination of slow-speed lugging saves wear and tear on engine. Furnished with 21" or 27" double-circuit fluid couplings for engines with #0 and #00 housings in the 100 to 600 hp range.

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Circle 444 on Page 19

It is noteworthy that more and more McGill bearing users are those who have revised their specifications on existing products to include McGill bearing design and performance advantages. Perhaps you have just switched to McGill — to the GUIDEROL series or to the new CAGEROL cage type needle roller bearing. Wouldn't it logically follow that you could be served even better by matching the best product and bearing design capabilities in the early development stage. Here McGill engineers can offer their experience with thousands of successful applications when it can be most easily applied to your new designs and your plans for increased product performance. It would offer further time and cost advantages. Most important, it is your best assurance that our extensive bearing research will complement your long range product development more specifically. Ask for McGill recommendations so that details can be worked out together.

1960*
in today's specifications

McGILL® BEARINGS

in tomorrow's product development

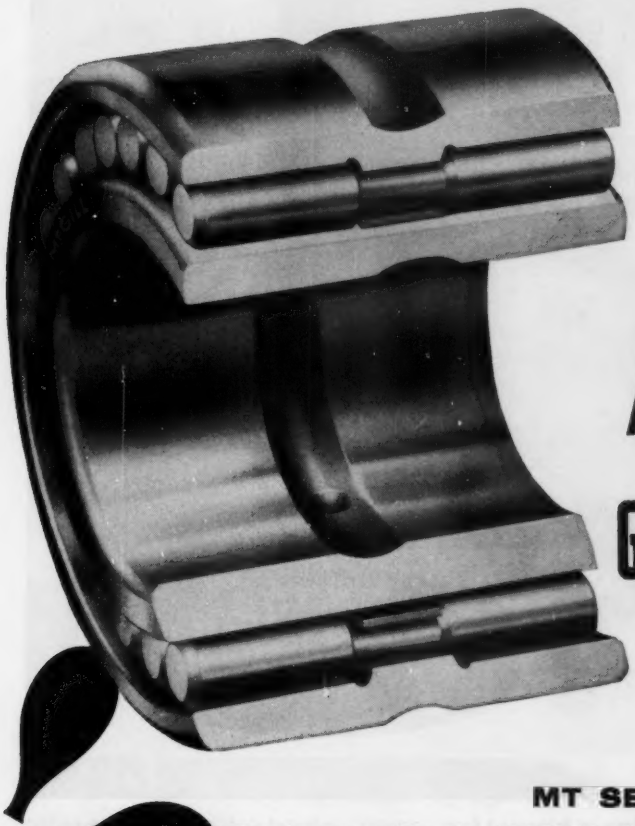
1970?

Write for McGill Brochure No. 760, a bulletin of facilities and abilities. It explains how we can help you on your bearing application problems in the early stages of product research and development.

FOR EXTRA LOAD CAPACITY IN MINIMUM RADIAL SPACE use

McGILL®

GUIDEROL® BEARINGS



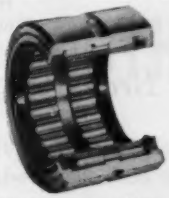
MT SERIES

Here is a compact bearing with high load-carrying capacity. Its full complement of race-width rollers is guided by an integral rail in the outer race bore, providing strength and skewing limitation that prevents binding under controlled misalignment. Rollers are guided at any operational angle from horizontal to vertical — self-cleaning through open ends. Available with or without separate inner ring in shaft sizes from ½" to 9¼". Dimensionally interchangeable with ordinary heavy duty needle bearings.

CT SERIES

Offer full type roller bearing capacity dimensionally interchangeable with ball and cylinder roller bearings of single and double row dimensions. The inner ring may be eliminated for further reduction of radial space.

SEALED—AND STILL COMPACT



No extra axial space needed for the sealed SG series GUIDEROL bearing. Seals are press-fitted securely in the outer race bore to provide the same width and performance advantages of standard GUIDEROL bearings. Contaminants are locked out, lubricants sealed in for those hard to re-lubricate applications. The SG series solves the problem of too-expensive auxiliary sealing assemblies.

Write for McGill's Bearing Catalog #52-A, for engineering data with dimensional and capacity information on McGill needle type roller bearings. Ask about special precision ball and roller bearings.

McGILL MANUFACTURING CO., INC., Bearing Division
200 N. Lafayette Street, Valparaiso, Indiana

engineered electrical products

McGILL®

precision needle roller bearings

Circle 445 on Page 19

FOR SHEER, SHEAR STRENGTH

Hydraulic Pressure tests on Bridgeport Brass Company's patented cladding system show perfect no-leak bonds over 3000 psi.

...*Bridgeport Brass Uses EASY-FLO 45 to Bond Their Clad Metals*

The "thick and thin" of cladding—from .010 to 2¾" in a combination of ferrous and non ferrous metals—calls for a bonding agent that will hold under the most severe forming and service operations. The answer, in every respect, is Handy and Harman's silver brazing alloy, EASY-FLO 45.

The uses to which these clad metals are put range from the kitchen to power plants, refineries, chemical and food-processing installations. Famous Bridgeport Copperware, used by housewives throughout the country, is made from a triple-clad metal consisting of a sandwich of two sheets of .010 stainless steel bonded to both sides of a sheet of .025 copper. The metals are joined in Bridgeport's patented process at *finish gauge*. So strong is the bond that no difficulty is encountered in the forming operations which follow.

Tube sheets, though their uses are far from "domestic," require the same "bondability." Tests at Bridgeport show that shear strength exceeds 20,000 psi. And this involves the cladding of carbon steel to as many different metals as stainless, brass, Monel and copper.

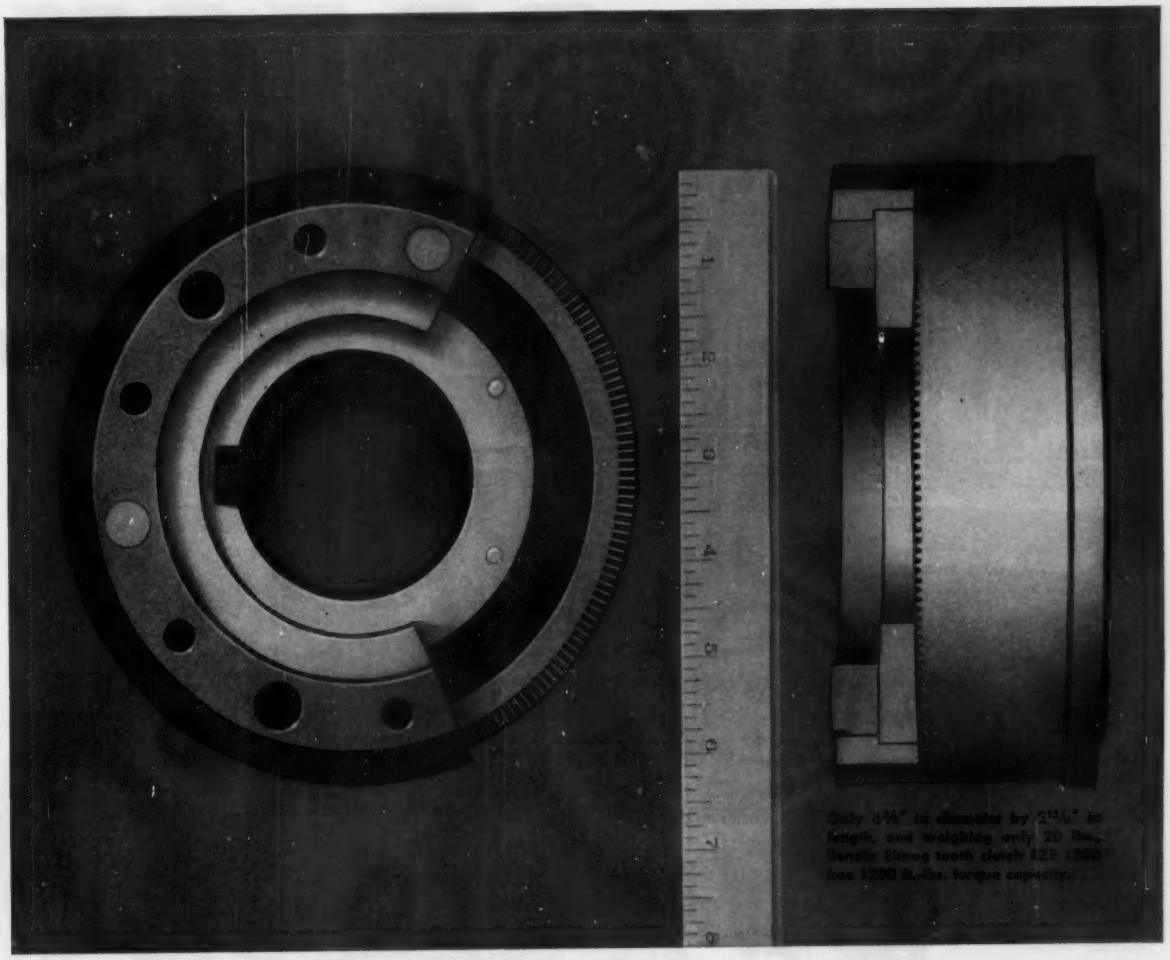
The primary need here, of course, is strength. EASY-FLO 45 has other attributes that are more than welcome under *any* metals-joining conditions: thermal and electrical conductivity, gas- and liquid-tightness, ductility, ease of application and economy are some more that we'd like you to know more about. We are ready indeed to further acquaint you with the significant benefits of silver alloy brazing by sending you our Bulletin 20, which is a clear and comprehensive introduction to one of the simplest, *saving* metals-joining methods in existence. Handy & Harman, 82 Fulton Street, New York City 38.

Your No. 1 Source of Supply and Authority on Brazing Alloys

HH

HANDY & HARMAN

General Offices: 82 Fulton Street, New York 38, New York



Designed for more torque in less space

BENDIX ELMAG* *(Electromagnetic)* TOOTH CLUTCH

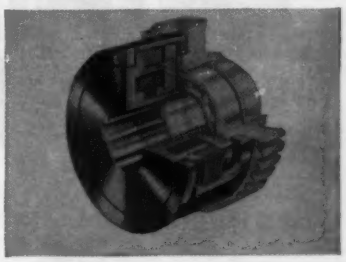
Machine designers now can provide for greater machine capacity, or space savings—or both—with the Bendix Elmag tooth clutch. This small, efficient package offers greater torque transmittal than is provided by other clutches of the same size.

It is more positive and simpler in design (only 3 parts) than other kinds of clutches. There is absolutely no idle torque—no connection between driving and driven members once disengaged. The Elmag can be disengaged under full load at any RPM, and engagement at relative speed is possible. The clutch's simple, bolt-on design makes it easy to mount; there are no additional splines or springs, no external disengagement mechanism.

*TRADEMARK

Elmag tooth clutches are designed to perform in either wet or dry applications. They are available from stock in torque capacities ranging from 40 to 4,000 ft.-lbs.

BENDIX ELMAG MULTIPLE DISC CLUTCH—Ideal for step-by-step acceleration of large masses. Disc stack is magnetically isolated. Wet or dry operation. Slip ring or stationary field design. Torque capacities: 10 to 16,000 ft.-lbs.

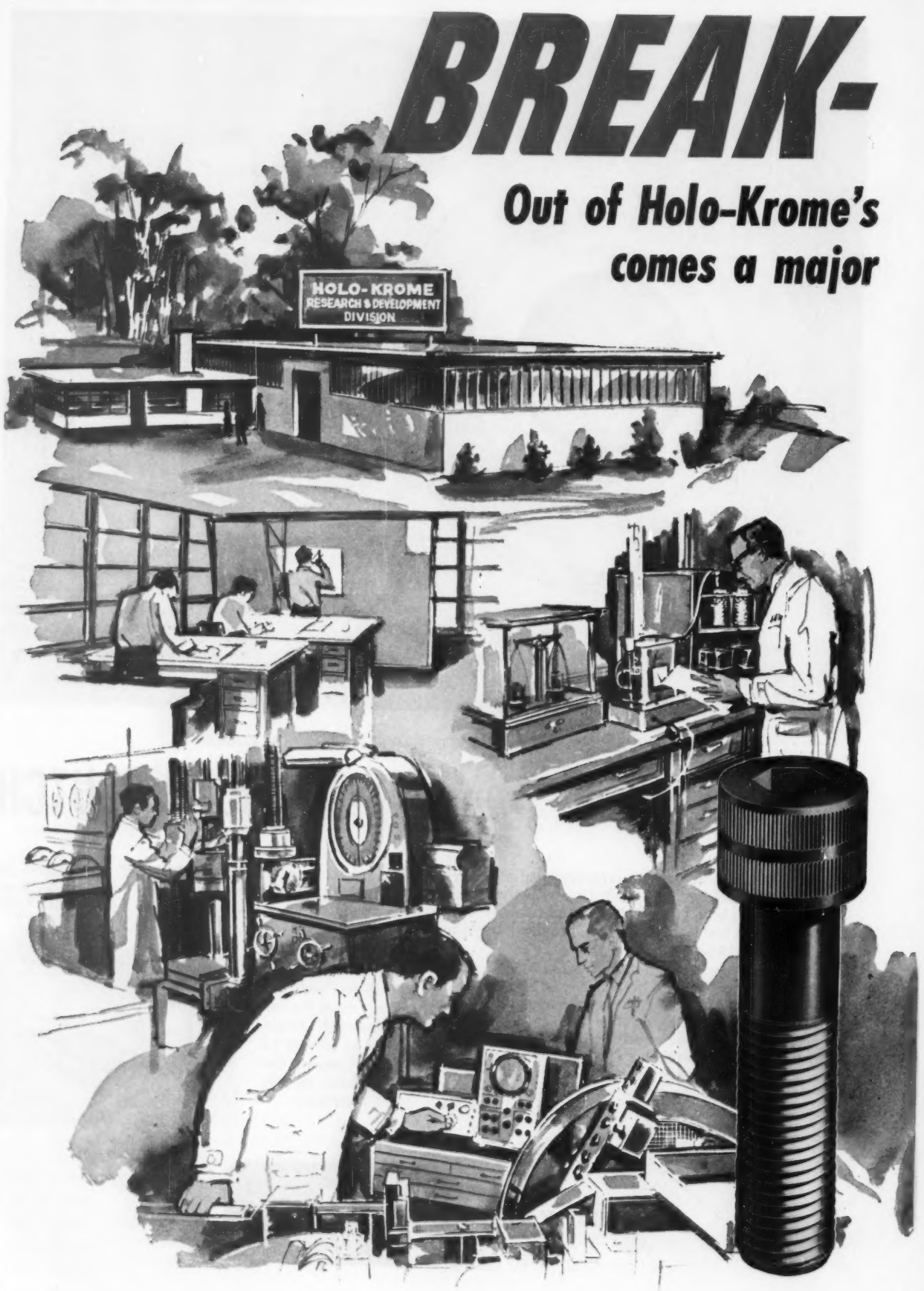


For full details, write

Bendix-Elmira
Eclipse Machine Division
Elmira, New York

THE Bendix CORPORATION

Circle 447 on Page 19


BREAK-
Out of Holo-Krome's
comes a major
HOLO-KROME
RESEARCH & DEVELOPMENT
DIVISION

THROUGH!...

Research & Development Division break-through in continuous warm forming...

*Thermo-Forged SOCKET SCREWS

The most dramatic innovation in socket screw manufacture in 28 years!

NOW, at last, after years of intensive research, Holo-Krome breaks the warm forming barrier with its revolutionary new electronic THERMO-FORGED process.

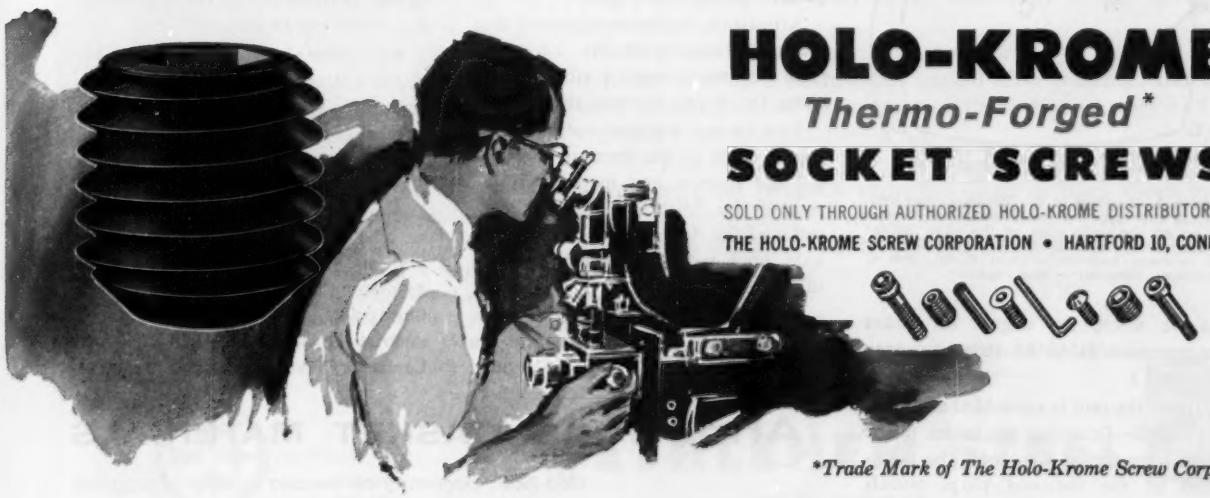
The first major break-through in socket screw manufacture since Holo-Krome pioneered and patented *Fibro-Forging* 28 years ago, Holo-Krome's unique new THERMO-FORGED process is *the first continuous, high-speed warm forming technique to be perfected!*

This revolutionary process *pre-conditions* the metal in patented apparatus for near-perfect forging conditions—by creating *just-the-right ductility* for the precise flowing of metals.

It gives Holo-Krome complete and continuous control and mastery over heat—and at unusually high speeds!

New and far higher standards in quality, precision and uniformity are now attained with Holo-Krome's exclusive THERMO-FORGED process. This unique process produces socket screws near-perfect in structure and of a uniform accuracy and quality never before possible!

Thoroughly researched in the laboratory and field-tested for more than two years, Holo-Krome's THERMO-FORGED Socket Screws are now available to industry through H-K's nationwide corps of authorized industrial distributors.



HOLO-KROME

*Thermo-Forged**

SOCKET SCREWS

SOLD ONLY THROUGH AUTHORIZED HOLO-KROME DISTRIBUTORS

THE HOLO-KROME SCREW CORPORATION • HARTFORD 10, CONN.

*Trade Mark of The Holo-Krome Screw Corp.

SEALING LIGHT FLANGES

Lightweight stamped or cast flanges often do not provide uniform compression on gaskets . . . and leaks result. Here's how a simple design change solved this problem and reduced gasket costs as well.

E. M. SMOLEY
Research Physicist
Armstrong Research and Development Center

There is an obvious cost advantage to using a lightweight stamped or cast flange wherever possible. Such flanges can, however, complicate the gasket problem. They usually are not rigid enough to distribute bolt loads evenly on the gasket. As a result, the flanges tend to bend or bow, reducing flange pressure on the gasket between the bolts and permitting leakage.

A typical problem of this type—the cast cover flange of a household gas meter—was recently referred to the Armstrong Research and Development Center. The outline of the flange and the distribution of the bolts are shown in Figure 1. The flange was gasketed with ⅛″ material, and flange bowing was suspected as the cause of troublesome leaks in the meter.

To measure the distribution of the bolt load around the flange, engineers used the Armstrong-developed "solder-plug" test. In this test, tiny plugs of solder are placed in holes drilled in the

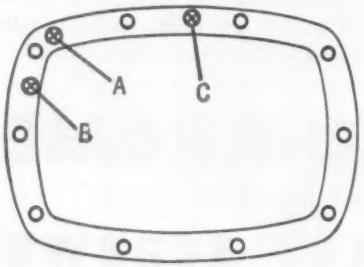


Figure 1. Diagram of the flange gasket indicating bolt spacing. Note bolts are farther apart on the sides than on the ends. Solder plugs were inserted at points A (beside bolt), B (midway between — short span), and C (midway between — long span).

gasket where the degree of gasket compression is to be measured (see Figure 1).

Then the unit is assembled and bolts tightened—flattening the solder plugs. When the flange is opened, the thickness of the flattened plugs reveals exactly how much the gasket was compressed at each test point.

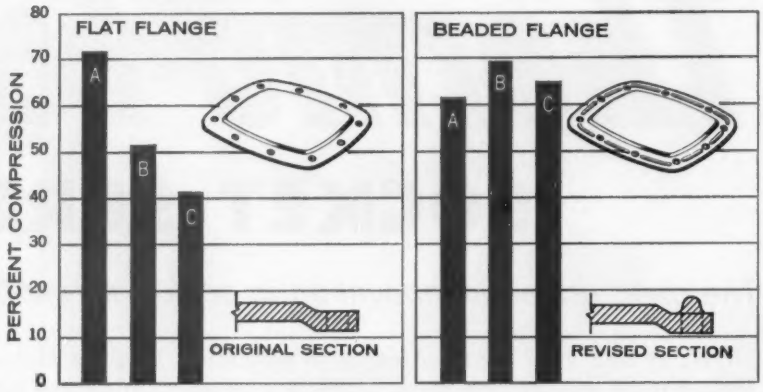


Figure 2. This shows the results of the solder-plug test on the original flange. Outline of the flange and sections is shown at right.

Figure 3. Results of the solder-plug test on the redesigned flange. Note how the bead (see section at right) improved distribution of flange load.

Figure 2 shows the results of this test on the gas meter flange. Note the difference of almost 31% between the minimum and maximum compressions on the gasket. Leakage occurred on this assembly because the flange at point "C" actually did not produce enough load to develop a seal with the gasket material being used.

Armstrong engineers suggested that the manufacturer modify his cover plate to incorporate a rib or bead along the flange between the bolts.

This change required only a minor modification of the forming tool and did not involve any increase in the cost of the finished part. The beads stiffened the flange sufficiently to provide much more uniform distribution of the bolt load.

This was proved by a second solder-plug test, the results of which are shown in Figure 3. With the beaded flange, the maximum variation in gasket compression is only 8.3%.

Not only did the new flange design stop the leaks, but it also allowed a reduction of 50% in the gauge of the gasket. A 1/16″ Armstrong cork-and-rubber gasket seals the new flange.

If you have a problem with a lightweight flange, or an application where a lightweight flange could save you money, perhaps our gasket engineering experience can be of help.

We will be glad to make suggestions if you will send details of the application to us. And if you do not already have a copy of the Armstrong Gasket Design Manual, we will be glad to send you one. Write Armstrong Cork Company, Industrial Division, 7109 Dean Street, Lancaster, Pennsylvania.

Armstrong GASKET MATERIALS
1860-1960 Beginning our second century of progress

Please direct inquiries to advertiser, mentioning MACHINE DESIGN

"Will the weld be as strong as the cylinder?"

Marion Power Shovel asked this question when we recommended two-piece forgings (at considerable savings over the former one-piece forgings) for use as jack cylinders in their giant electric shovels. We answered "yes" . . . and tests show the weld metal has higher mechanical properties than the minimum physicals required for the cylinder.

BECAUSE THE HOLE *at the cylinder end is small, machining the sleeve before the head is welded on is lots easier and faster than machining the former one-piece forging. There's more room to work; the tool can get a good grip on the piece, hog out the metal, instead of pick it out. The savings are more than enough to offset the added welding cost.*

FOUR FORGED-AND-WELDED *"equalizing" cylinders, like those above, are used to keep the upper frame of this Type 5761 Electric Shovel level during operation. Made by Marion Power Shovel, Marion, Ohio, this shovel's dipper has a 65 cu yd capacity.*

Forged from manganese-vanadium steel, this sleeve-and-head cylinder weighs 22,690 lb.

The sleeve itself is 9 ft, 10 in. long, with a body OD of 45 in. Flange OD is 48 in.; flange ID, 35¼ in. The wall is 5-in. thick. To produce it, we upset, punch, hollow-forge, double-normalize and temper. Then we finish-machine to size, including the weld bevel on the end of the sleeve.

We forge the head as a disc of 49 in. diameter, and 11-in. long. Then we finish-machine it to size (45-in. OD, 9¾-in. long), including the weld bevel, and treat it the same as the sleeve.

The two pieces are then assembled and welded. The cylinder receives a stress-relief anneal after welding, and the weld is radiographed to assure soundness. Excess weld on the OD and ID is then machined off.

If you have a forgings problem, Bethlehem is a good company to get in touch with. We think as hard about one-pound drop forgings, as we do about 200-ton press forgings. To start us thinking about your forging, call the Bethlehem sales office nearest you.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.
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Steel — *For strength . . . economy . . . versatility*

BETHLEHEM STEEL

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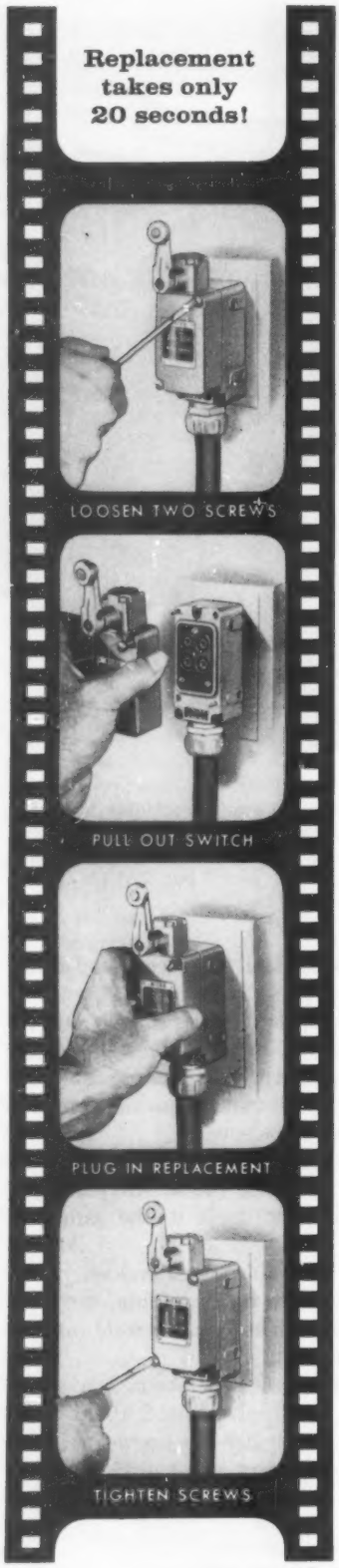


HOW MICRO SWITCH "Plug-in Limit" switches keep selling your machines...

The limit switches you specify on your machines can be salesmen or "sore spots." That's why more and more machine tool builders are depending on MICRO SWITCH reliability. And, MICRO now offers the most complete line of "Plug-in Limit" switches in the industry. These timesavers offer many special advantages when you specify them for your equipment:

1. MEASURABLE DOLLAR SAVINGS

Actual case histories prove the 20-second replacement time sometimes saves hundreds of dollars in production time over ordinary limit switches. The switching unit plugs in like a radio tube. Receptacle need not be removed. Your customers will appreciate this reduction of down time.

2. NINE DIFFERENT ACTUATORS

The one receptacle is designed for any of the nine styles of actuators. Flexibility for the design of your machine; adaptability later if necessary.

3. AUTOMATIC STATION CONTROL

Your customer will be able to automatically disconnect any station on his line by simply pulling out the correct MICRO "Plug-in Limit."

4. BEST SEALS AVAILABLE

The "O" Ring and gasket seals on these switches are the best available. Greater reliability for your machines, important because with customers, every actuation of a switch is a test of your equipment.

See the Yellow Pages for the location of the nearby MICRO SWITCH Branch Office and ask for the full story on how "200LS" Series "Plug-in Limit" switches can help sell your machines. Or, write for Catalog 84.

75th YEAR HONEYWELL PIONEERING THE FUTURE

MICRO SWITCH Precision Switches

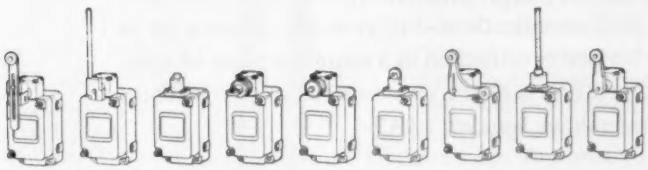
The "200LS" line has rugged terminal blocks with heavy No. 8 terminal screws for easy wiring and sturdy, molded barriers to protect plugs from damage. Operating head mounts in four positions.

5. FLEXIBLE MOUNTING

May be side-mounted or back-mounted for a possibility of 24 different mounting arrangements.

6. WIDER SELECTION

MICRO SWITCH offers many variations to fit specific needs. All have the same receptacle size for easy interchangeability. There's sure to be a model that fits your design needs.



MICRO SWITCH . . . FREEPORT, ILLINOIS
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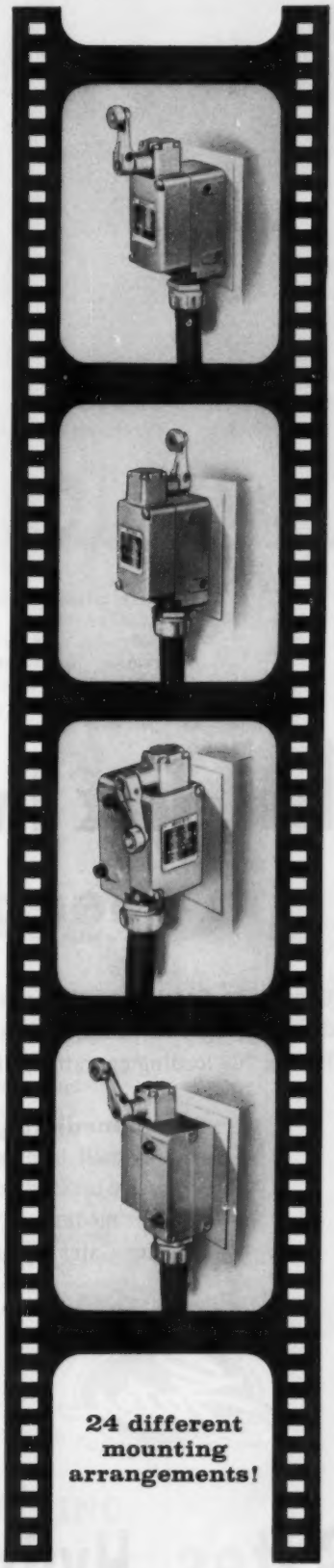

Honeywell
MICRO SWITCH Precision Switches

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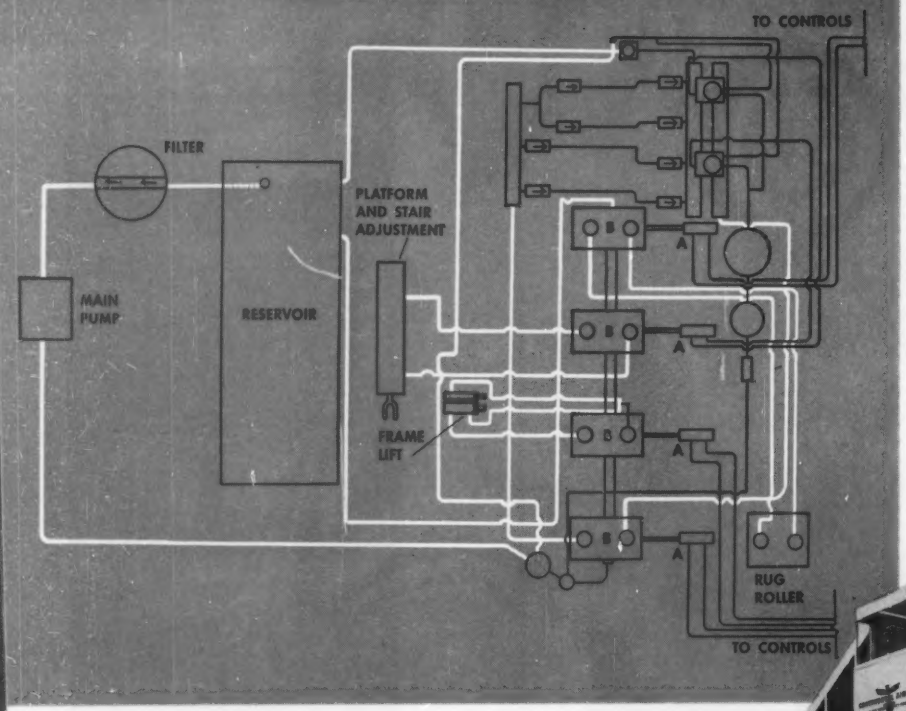

Simplified schematic of hydraulic system shows Gates Hydraulic Hose in white line, other elements in black. Air from 15-psi pneumatic control system enters slave cylinders A, activating high-pressure hydraulic valves B, which in turn operate mechanisms for platform and stair adjustment, frame lift, and rug roller. Hydraulic valves also operate stabilizers (not shown).

Deluxe passenger ramps manufactured by Bil-Jax, Inc., of Archbold, Ohio, for Continental Airlines "Golden Jet" service feature completely self-contained operation: raising and lowering of ramp, rolling out Gold Carpet, and driving truck, all from a single set of controls.

bil-jax inc. selects Gates Hose to speed "Gold Carpet" service!

Chosen by Continental Airlines to develop and produce the special ramps required for the carrier's Boeing 707 loading operation, Bil-Jax in turn selected Gates Hydraulic Hose because of "...the quality and reliability of the product, its availability, and the technical assistance available from Gates representatives."

Immediately avaliable in all major markets. Gates Hydraulic Hose — built to meet or exceed SAE specifications — is available nation-wide in wire-braided and horizontal-braided construction in a complete range of sizes, for medium-pressure or high-pressure use. Ask your nearby Gates Distributor for Gates Hydraulic Hose Assemblies booklet, IH 43.

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TPA 467

Gates Hydraulic Hose / Made in a Full Range of Sizes Medium-Pressure, High-Pressure

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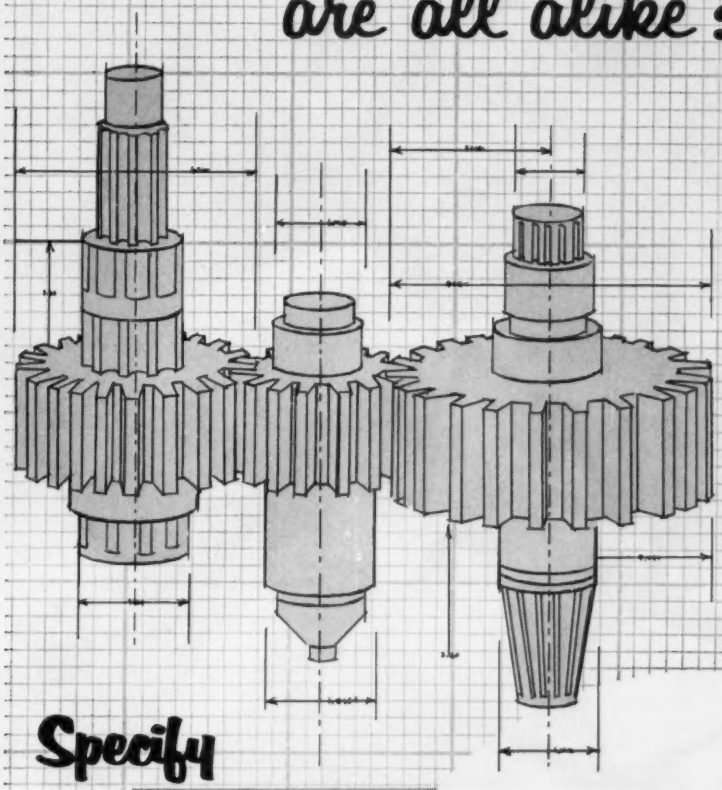
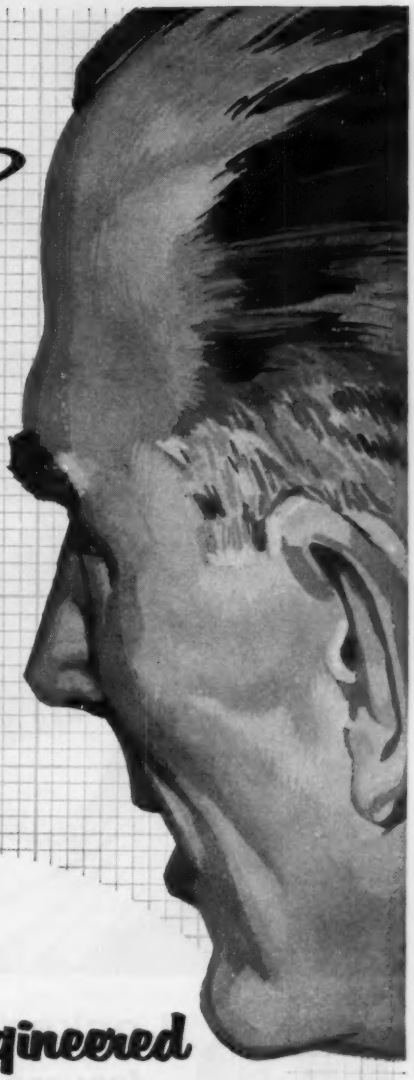
Who says Shafts are all alike?





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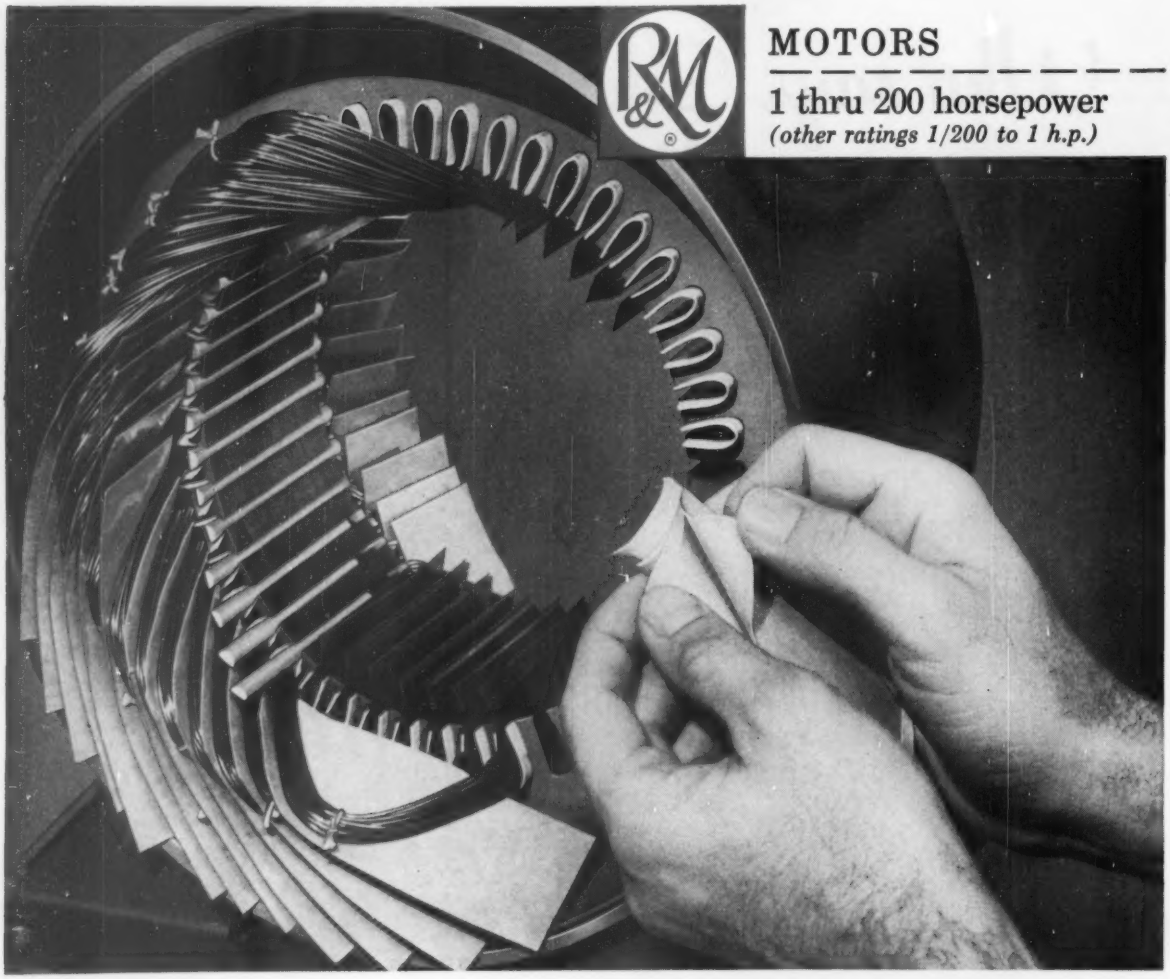
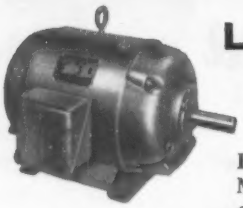


MOTORS

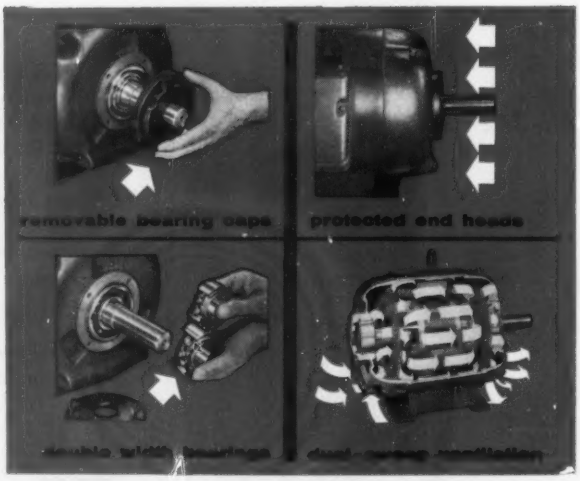
1 thru 200 horsepower
(other ratings 1/200 to 1 h.p.)



Locked-In, Laminated Insulation
Insures Longer Life for your R&M Motor!

Each slot-cell in your ROBBINS & MYERS motor grips a triple layer of insulation around the windings. Installing these insulation "sandwiches" is a time-consuming job but it pays off in long motor life. Mylar* laminated to rag paper is first inserted. Reinforced edges prevent slipping and scuffing. The dielectric qualities of Mylar* (8 times that of conventional insulation) combined with its resistance to tearing and aging affords permanent protection; the rag paper backing acts as a cushion against abrasion and punctures. A second layer of insulation is inserted to eliminate the danger of weak spots. The wire coil, coated with triple resin insulation, is inserted and a third layer of insulation is placed over it. Insulation is placed between the coil ends, wedges are inserted to hold the coil firmly in place and the stator is twice dipped in special insulating varnish and baked after each dip, thus forming an armor-like coating. Coil ends are coated with a moisture-proof sealer. This is insulation you can trust, yet it's yours at standard prices! For more details write for Bulletin 520 MD

**DuPont registered trademark*



ROBBINS & MYERS, INC.

motors, household fans, Propellair industrial fans, hoists, Moyno industrial pumps

SPRINGFIELD, OHIO · BRANTFORD, ONTARIO

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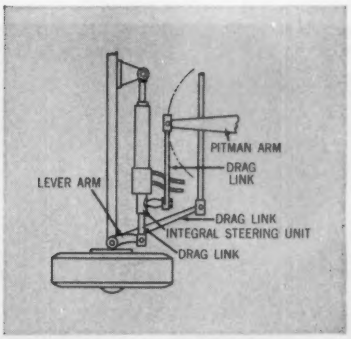
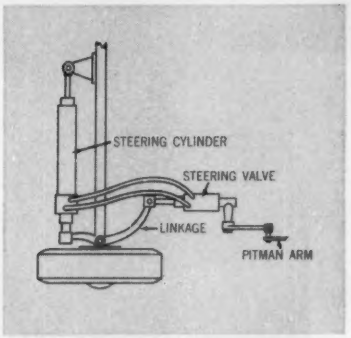
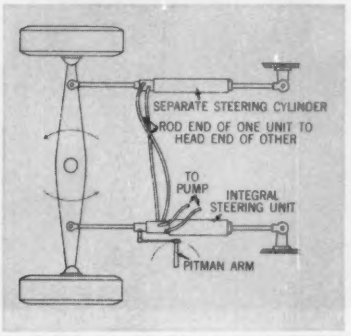


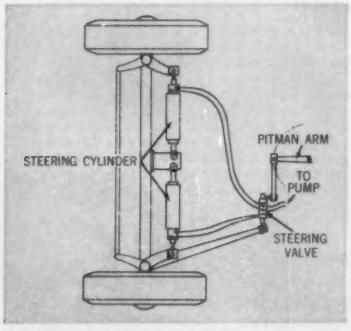
INTEGRAL LINKAGE system combines servo valve and steering cylinder with rod end fastened to frame and valve end to drag link.



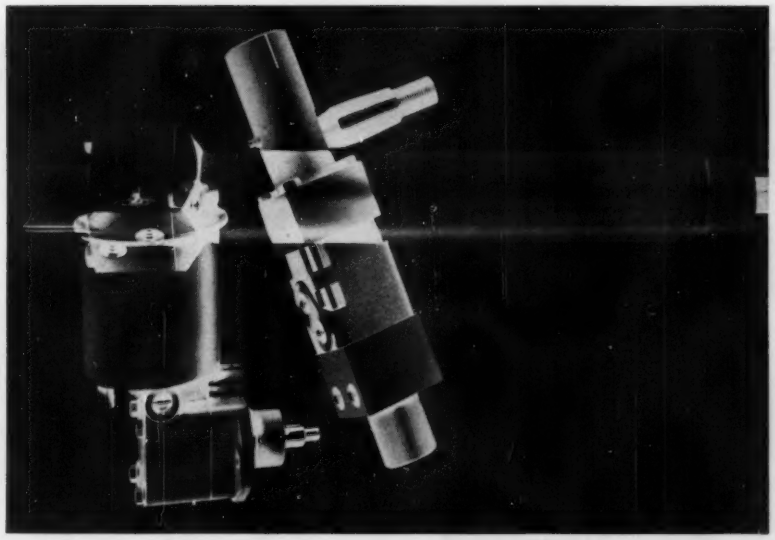
REMOTE LINKAGE system has separate servo valve and cylinder. Servo is mounted at most convenient point with cylinder located for maximum thrust.



COMBINED INTEGRAL-REMOTE system servo valve controls both cylinders. When integral unit (bottom) extends, remote unit (top) retracts.



REMOTE DUAL system uses one remote servo valve, offers best possible thrust conditions plus considerable installation flexibility.



FOR AXLE LOADINGS 1500—128,000 LBS.

New VICKERS. power steering systems use standard units, offer custom performance

Performance benefits normally associated with custom designs plus the economy of standard, production-built components are combined in new Vickers power steering systems. The cylinder, servo valve, and pump—key elements in the power steering system—are always perfectly matched to system needs because Vickers builds the *complete system.*

Either remote or integral systems can be provided for the complete range of axle loadings from 1,500 to 128,000 lbs. All vehicles use the same servo valve—holding engineering and installation time to a minimum and reducing inventory requirements for manufacturers building several sizes or types of equipment.

Operating Economy—Systems are designed for high pressure operation (to 2000 psi) permitting smaller pumps, lines, reservoirs, valves and cylinders to be used. Further economy results because each basic size of steering unit is capable of a wide range of axle loadings. This permits some manufacturers to use a single size of steering unit for their complete line of vehicles. For example, in a single cylinder installation, the Model SC-26 cylinder can be used for any axle loading from 16,000 to 64,000 lbs.

Further economy over the life of the system results from the minimum number of moving parts required by this design and from its rugged construction. All cylinders are double walled to eliminate the common hazard of functional damage to cylinder walls from flying debris. Exclusive design vane pumps last longer, permit easy cold weather starting because pumping doesn't begin until after engine fires and comes up to speed.

Complete Responsibility – Both the equipment builder and ultimate user benefit because Vickers designs and builds all system components. In addition, a staff of power steering specialists is available to work with customers on specific development and application problems.

When equipment is being built for the export market, worldwide stocks and complete interchangeability of all parts made in Vickers plants throughout the free world offer added benefits.

More Data – Design advantages, dimensions, ratings, and other data are available in Bulletin titled "New Complete Power Steering Systems." Write for this 20 page Bulletin M5110.

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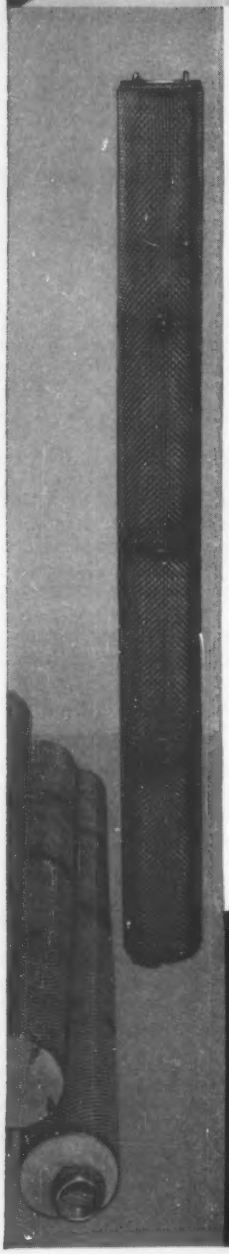

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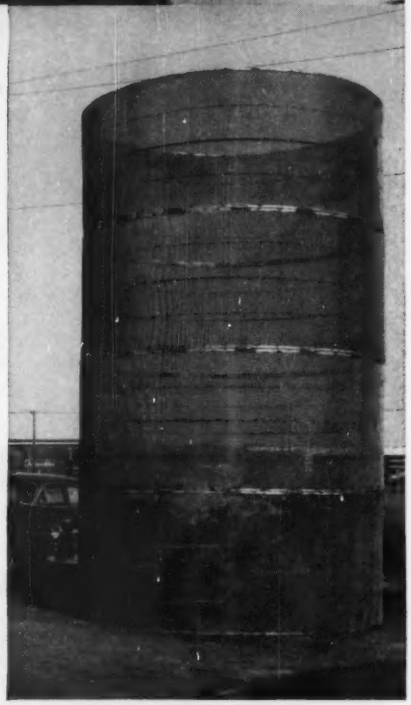

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Bunting® NYLON

An additional Bunting service

NOW. . . *available from Bunting distributors all over America*

Bunting nylon puts at the disposal of engineer and manufacturer a tested material for bearings and parts that fully meets all requirements in which the unique qualities of nylon are desired. It is strong, tough, heat resistant, rigid but with high embeddability, and practically self-lubricating. There are many and various applications where Bunting nylon will improve performance.

- Bunting nylon is available from stock in solid rods, extruded tubes, tubular bars, pressure tubing and plate.
- Unusually wide range of sizes and shapes provides low cost fabrication and minimum of machining.
- It is readily machined, blanked, ground, turned and welded or bonded with adhesive. High production speeds can be maintained.

Bunting nylon expands Bunting's comprehensive service—now supplying bearings, parts and bars made of cast bronze, sintered metals, aluminum and nylon. Available from stocks or made to blueprint for production and maintenance requirements.

EASY TO TRY IT

Small lots of special design Nylon bearings, or parts can be made immediately by fully equipped emergency machine shops in Bunting branches. The wide range of sizes and shapes of Bunting Stock Nylon makes the alteration of a stock item easy and economical. Your local Bunting Distributor can arrange for such work.

write for this Nylon Catalog and Listing No. 32

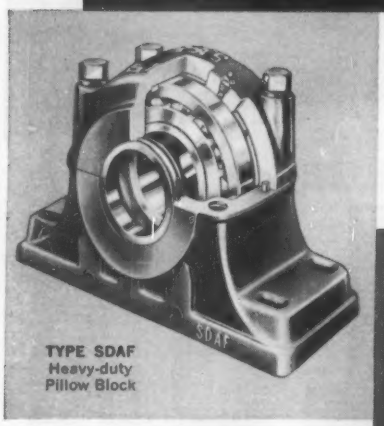
the BUNTING Brass and Bronze Co.
TOLEDO 1, OHIO

BEARINGS, BUSHINGS, BARS AND SPECIAL PARTS OF CAST BRONZE, SINTERED METALS AND ALUMINUM } *write for Catalog No. 58*

Circle 456 on Page 19

TYPE SAF
Ball or Spherical Roller
Bearing Pillow Block

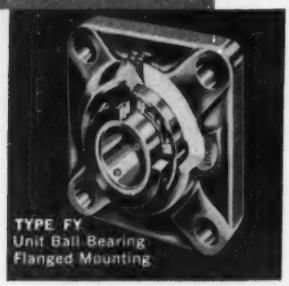
Can you get these "special" qualities in "standard" pillow blocks?



TYPE SDAF
Heavy-duty
Pillow Block

TYPE SY
Unit Ball Bearing
Pillow Block

TYPE SES
Unit Rubber-flex Ball
Bearing Pillow Block



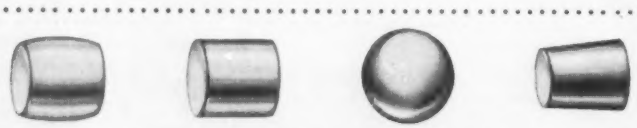
TYPE FY
Unit Ball Bearing
Flanged Mounting

Most pillow blocks offer easy assembly and rugged housings. But can they offer you low friction, self-aligning bearing operation and efficient sealing as well?

They can—if they're the SKF pillow blocks, and flanged mounting, shown here. Type SAF, for example, comes equipped with low-friction ball or spherical roller bearings that are *inherently* self aligning. And these bearings are effectively protected by Triple-Seal rotating rings. Abrasives and corrosives can't get to them—oil or grease can't drip out.

Yet this is a standard SKF pillow block, that is competitively priced in spite of its combination of extra features. We make it for shaft sizes from ¾" to 10½", for mounting directly or with an adapter. A cast steel housing (SAFS) is available for heavy duty applications.

For details, call one of our twenty-four offices. 5938



Spherical, Cylindrical, Ball, "Tyson" Tapered and REED Miniature Bearings

EVERY TYPE—EVERY USE

SKF®

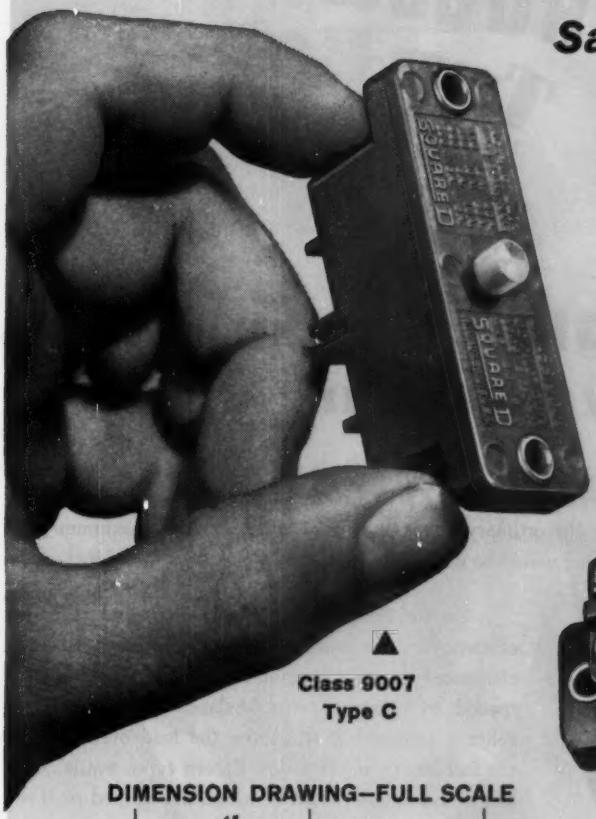
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.

*REG. U.S. PAT. OFF.

Circle 457 on Page 19

Now!..

SQUARE D PRECISION *SNAP* SWITCH AVAILABLE WITH 2 POLES!

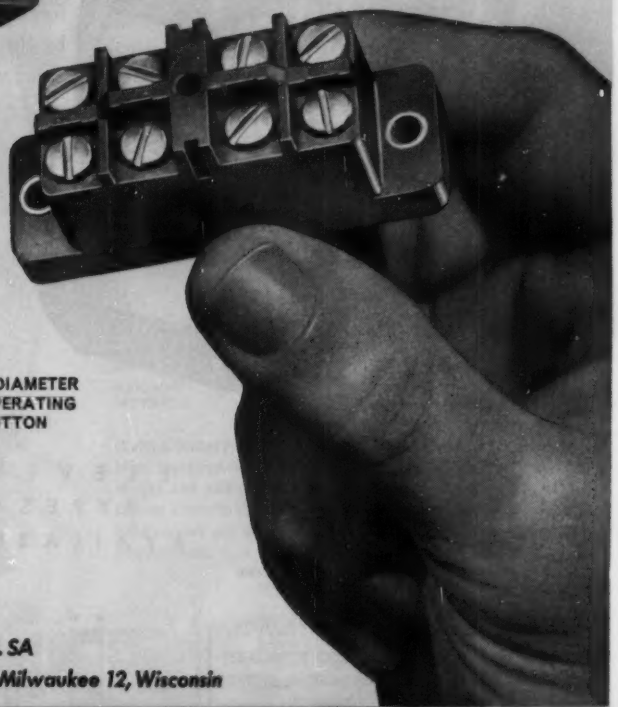


Class 9007
Type C

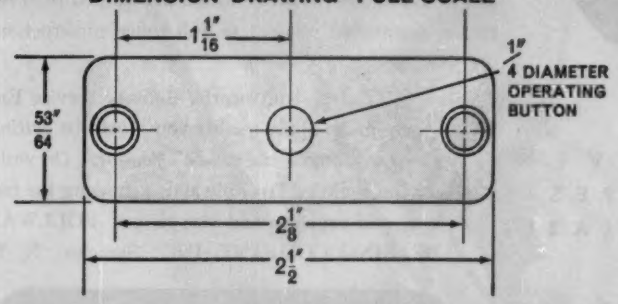
Same size and mounting as single-pole switch

Here's a precision snap switch which combines 2-pole versatility with high electrical ratings—and takes no more space than a single-pole switch!

The new switch is available either single-throw (2 normally open or 2 normally closed) or double-throw, and like the single-pole switch, it features: double-break contacts—large screw-type terminals—strong melamine case—simplified mounting...a design which assures reliability, precise repeat accuracy and long mechanical life.



DIMENSION DRAWING—FULL SCALE



Write for details. Square D Company, Dept. SA
4041 North Richards Street, Milwaukee 12, Wisconsin

SQUARE D COMPANY

wherever electricity is distributed and controlled

For a money-saving balance

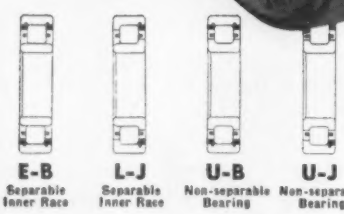
between maximum performance and moderate cost . . .

ROLLWAY Tru-Rol® BEARINGS

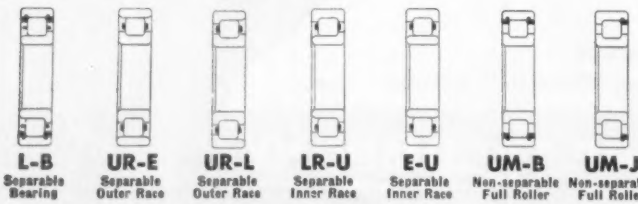
Give you more for your bearing dollar

For those hundreds of in-between applications where performance requirements are more exacting than those provided by the ordinary commercial bearing, but where maximum precision would be unneeded precision – specify Tru-Rol for the job.

Tru-Rol Bearings provide above-commercial-grade efficiency . . . at worthwhile savings in cost. Internal clearances are closely controlled. Rollers are equally spaced to eliminate- out-of-balance vibration. Each roller is crowned to distribute the load evenly along the full length of the roller. Eleven types available in single and double width bearings, in stamped steel retainer, segmented retainer or full roller construction.



ELEVEN TYPES AVAILABLE



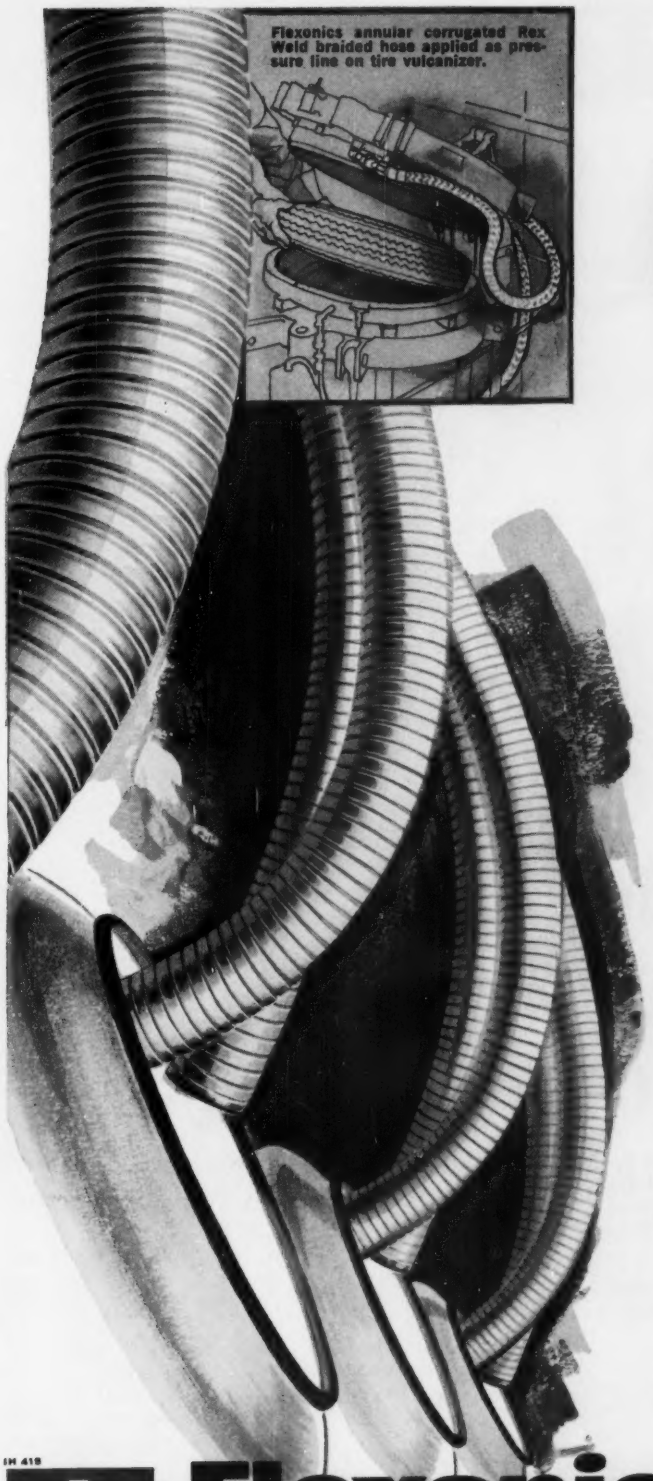
Ask your nearby Rollway Service Engineer to detail the quality you *should be getting* in your "commercial grade" bearings. Or write for the Rollway Tru-Rol catalog showing the full line, and capacity and size ranges. ROLLWAY BEARING COMPANY, INC., Syracuse, N. Y.

ROLLWAY® BEARINGS

COMPLETE LINE OF RADIAL AND THRUST CYLINDRICAL ROLLER BEARINGS

ENGINEERING OFFICES: Syracuse • Chicago • Toronto • Cleveland • Seattle • San Francisco • Boston • Detroit • Pittsburgh • Houston • Philadelphia • Los Angeles

Circle 459 on Page 19



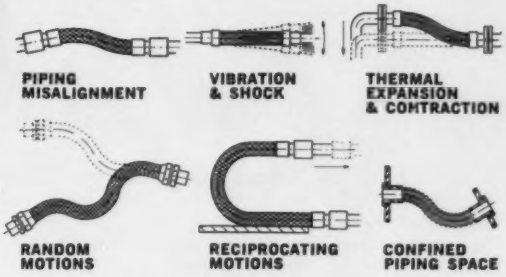
Meet any requirement for

METAL HOSE

with Flexonics engineering and big line of standards

Whatever your application requirements, Flexonics greater depth of product and experience means correct, quick, and *economical* solutions. Often, the most unusual design requirements are met with Flexonics extensive line of standard hose and fittings. You'll find Flexonics product and application engineers *more adept* at pin-pointing the performance standards the job demands. Depend on them.

Controlling effects of pressure and temperature in conveying solids, liquids or gases is the job of metal hose. Motion (illustrated below) is another factor common to all piping problems in one form or another. Flexonics sales engineers are "pipe motion specialists" . . . capable of anticipating and providing for any need in this direction.



(Left) A battery of Flexonics RT-6 galvanized steel hose assemblies installed in the tablet coating room of an internationally recognized pharmaceutical corporation. One hose is a hot air carrier (110°F), to hasten drying of tablet coatings. The other hose draws off excess air from the large pans, preventing powder dust.

IH 419

Flexonics
corporation

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EXPANSION JOINTS | METAL HOSE | SYNTHETIC HOSE | BELLOWS | AERO/SPACE COMPONENTS

SUBSIDIARY OF CALUMET & HECLA, INC.

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FLEXONICS CORPORATION
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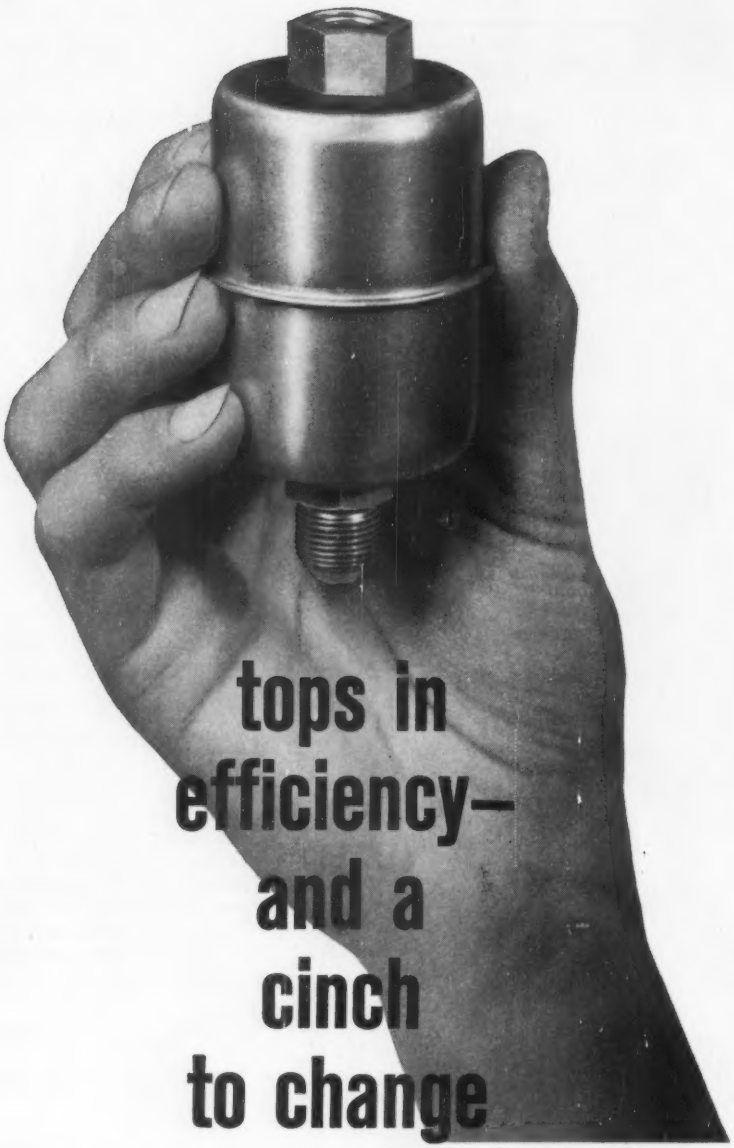
Please send me my personal copy of the Flexonics Metal Hose and Fittings Design Guide, covering in detail Flexonics products and services.

Circle 460 on Page 19



tops in efficiency– and a cinch to change

HERE'S ALL YOU DO! Unscrew the two fittings that join the Purolator GF-11 Filter to the fuel line. Throw away the dirty filter. Fasten in the replacement. Now you're ready for 5,000 miles of efficient, trouble-free fuel filtration. Total time involved? *Less than 5 minutes.*

MOTORS RUN SMOOTHER . . . Because this Micronic® filter removes dirt, metal, rust, scale and gum . . . even microscopic particles down to 5 microns.

ADAPTABLE TO ALL GASOLINE ENGINES. Purolator fuel filters like the GF-11 shown above, are standard equipment on most 1960 cars. However, it can be incorporated into the fuel system of almost *any* gasoline engine – automotive, portable or marine.

MORE ADVANTAGES. Easy installation and replacement is a big reason for the popularity of the Purolator GF-11 Fuel Filter. But here are more:

•PEAK EFFICIENCY. Because Purolator replacement filters are inexpensive, and easily installed, chances are they'll be replaced at proper intervals – *and always work at peak efficiency.*

•LONGER SERVICE LIFE. Because of the special pleated construction of the filtering unit, the GF-11 has fully *70 square inches* of filtering surface. It operates longer at peak efficiency.

•COMPACTNESS. The GF-11 measures about 3" by 1⅞". It can be installed either horizontally or vertically.

•VERSATILITY. The GF-11 Filter can be installed as an O. E. M. item on practically any gasoline-engine – from sport cars and garden tractors to power mowers and midget racers.

For complete information on the GF-11 and other Purolator filters, write to Purolator Products, Inc., Department 3849, Rahway, New Jersey.

Filtration for Every Known Fluid

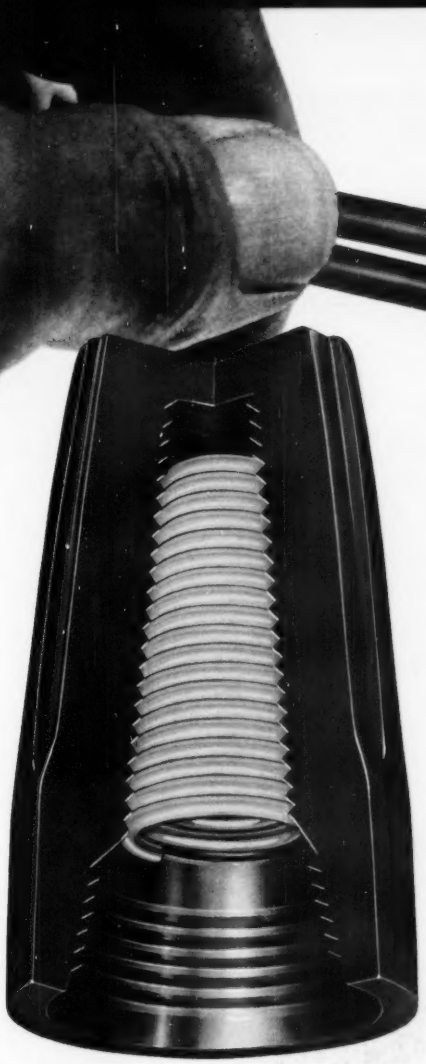
PUROLATOR

PRODUCTS, INC.

Rahway, New Jersey, and Toronto, Ontario, Canada

Circle 461 on Page 19

Circle 462 on Page 19→



IDEAL

SPECIFIES KEYSTONE WIRE FOR WIRE CONNECTORS

"We use Keystone MB Spring Wire because we know our spring coils will meet rigid specifications. That is the secret of the success of our solderless wire connectors," says Paul Cherry, Plant Superintendent of Ideal Industries, Inc., at the Petersburg, Illinois, plant.

Ideal Industries were the original designers and manufacturers of wire connectors for electric wiring in appliances and home construction. Their "Wire-Nut"* connector with a copper-coated conical spring, securely contained in a plastic cone, is the standard for electrical contractors the world over.

Ideal, a major supplier to world markets, emphasizes quality control by continuous inspection of their tiny wire spring coils.

Keystone's metallurgical and research engineers worked closely with Ideal Industries, Inc., to develop a special MB Spring Wire for its product. Close diameter tolerance, uniform temper throughout the coil, special surface for copper and cadmium plating and lubricant qualities for high-speed production were the results of this research effort.

Delivery is made in moisture-proof fiber drums for protection of plating quality finish during shipment or storage.

Take a cue from Ideal Industries and let Keystone solve your wire problems. Call your Keystone Wire Representative soon or write us for details; we will be pleased to help you.

Keystone Steel & Wire Company, Peoria 7, Illinois

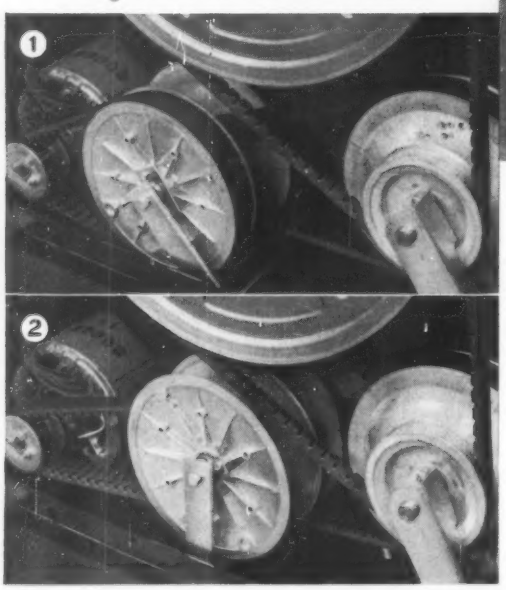
KEYSTONE

WIRE FOR INDUSTRY

*Reg. TM Ideal Industries, Inc.

IT'S LIGHTER THAN YOU THINK!

WITH HIGH STRENGTH THIN-WALL SECTIONS WHEN DIE CAST WITH ZAMAK



A single zinc die casting—a conical disk 7½" in diameter—used in four different positions, makes up this speed changer mechanism for the General Electric Combination Washer-Dryer.

Cast with hub and radial reinforcing ribs and a projection-recess interlocking system (see view above, with one disk cut away to show cross section) two of these parts are pressed, back to back, on a bronze bearing to form a movable drive ratio adjustment. Two single pieces, locked on the ends of the tube, complete the dual-pulley assembly.

In position 1 (at left), the mechanism provides a regulated low speed for washing, rinsing and drying cycles. Moved upright, as in position 2, the drive is changed from an 8 to 1 ratio for centrifuging speeds during the water-extracting cycle.

Zinc die castings, because of their high strength in thin-wall sections, their dimensional accuracy, smooth surface and low cost, are the logical and obvious answer to the problem of producing these heavy-duty appliance parts.

HORSE HEAD® SPECIAL ZINC AND HORSE HEAD ZAMAK ARE PRODUCED BY

THE NEW JERSEY ZINC COMPANY

DEVELOPERS OF THE ONLY STANDARD ZINC DIE CASTING ALLOYS IN USE TODAY

160 Front Street · New York 38, N. Y.

HORSE HEAD PRODUCTS ®

Circle 463 on Page 19

DESIGN
September 1, 1960

Preserving Status

HOW many design engineers fully recognize the broad scope of their own function in industry? Sometimes it seems that their failure to push hard on every front of their responsibility has weakened their status in a company.

It is the basic function of design engineering to translate ideas into hardware that can be sold at a profit. Engineering education emphasizes the technical aspects of design engineering. Consequently that is where engineers perform best and feel most at home.

Inadequate preparation for the "can be sold at a profit" part of the function has created a vacuum into which specialists have moved. One aspect of design for profitable sale which design engineers have sometimes permitted others to take over is so-called value engineering.

These specialists who analyze a design for lower cost make a tremendous impression on money-minded management. The result of their work is easily understood by nontechnical sales and financial types who are unable to appreciate the vital technical contributions of the design engineers.

Value engineering can support its story with innumerable case histories of components and assemblies redesigned for production at unit costs which are but a fraction of prototype costs.

A gullible management, at this point, can all too easily fall into the trap of thinking of value engineering as a significant new technique for increasing profit. The simple fact is that whatever is done in the name of value engineering can be done more effectively within the design engineering organization. It simply means exercising some of the neglected techniques of good design.

Nothing can cause a design engineering organization to lose status more quickly than the formation of an outside group with authority to second-guess—perhaps reporting directly to top management. The best protection against such an eventuality is to build strong design-for-production capability within, keeping value engineering as an integral part of product design.

Colin Carmichael

EDITOR

How to use

Functional Tolerancing

to take full advantage of the concepts of maximum and minimum material conditions

Recently issued drafting standards codify many—but not all—practices essential to the complete specification of functional requirement in parts drawings. Here are recommendations on how to handle some of the troublesome topics that remain.

FUNCTIONAL requirements are becoming of prime importance on engineering drawings today, and inspection and processing needs are supplemental. This trend is recognized in new standards issued by several bodies in recent years.

Added functional details in drawings have been required by a shift in practice within industry. In the past, for example, most drawings left decisions about geometric tolerances to the manufacturing and inspection departments. In some respects, hence, engineering drawings today must try to express what has been known and used in inspection departments for many years.

Current standards go far in recommending how many of these requirements should be formalized on drawings. But they, by no means, are complete in coping with all practical problems that arise. In this article, some of these troublesome points are examined and solutions for them are proposed. Particularly, this discussion covers the concept of maximum-material condition, MMC, and practices for the expression of product geometry.

Unspecified Geometry

If the problem is to decide maximum limits of geometry without specific reference to errors of geometry, the best solution relies on the rule that the form of the finished part must fall within the boundaries determined by size dimensions. Well known standards make this point (MIL-STD-8, ASA Y14-5-1957, and SAE Section A7).

Applications of this rule are shown in Fig. 1 to 7 in the table *Interpretations of Size and Geometry Tolerances*. Of course, size tolerances must be known in order to determine maximum errors in geometry. Diameters must have their mean values if the worst conditions exist in the cases of straightness, squareness, concentricity, and location. Dependence on size to control location, Fig. 7, is an unusual condition. Not specifying concentricity (actually, another method of location) is more common. However, when location of diameters is not specified, interpretation should be as in Fig. 7.

Specified Geometry

When geometry is spelled out, the general rule that all geometry must be within size limits is not reliable. Some errors in geometry can exist outside the sizing zones without the condition being picked up in a sizing check. Fig. 8 to 15 show where this

REGINALD E. STANLEY
Checking Supervisor
Sundstrand Aviation
Div. of Sundstrand Corp.
Rockford, Ill.

can happen and the resultant worst conditions. In these examples, neither the sizing *range* nor the geometry *range* may be violated. Fig. 8 through 11 are illustrations of geometry tolerance contained *within* the sizing zone. In each of these examples, it is impossible to allow the geometry to fall outside the sizing tolerance without the part being out of print. The sizing check would reject such a part.

However, in Fig. 12 through 15, a sizing check would not pick up a condition where the geometry has extended the original size envelope. For instance, the part in Fig. 12 would pass sizing check 0.99-1.00. The criterion for the sizing check would be that it had to be measured at right angles to one of the two sides in question but not necessarily parallel to surface *A*. The lack of parallelism between the line of measurement and surface *A* is simply the error allowed for squareness.

Usage of MMC

When size and geometry summate, Fig. 12, 14, and 15, the outline derived is often called the "effective size" of the feature. This effective size will be the worst condition of the part and is the value which must not be violated in order to prove either fittability or minimum stock. It is possible to subtract from one value while adding to the other, and still maintain the same effective size. This, in essence, is the basis of the maximum-material concept.

In Fig. 13, for example, the allowance of the MMC concept would say that as long as the effective size of 0.501 is maintained, the squareness error can be increased as the size decreases, and the size may increase as the squareness decreases. The limits of this variation would be controlled by the original values assigned. The squareness error could increase from 0.001 to 0.011 since the size could decrease from 0.500 to 0.490. The effective size could never exceed 0.501. The size could increase from 0.500 to 0.501 since the squareness error could decrease from 0.001 to 0.000. The maximum squareness error could be 0.011 provided the diameter were 0.490. The maximum diameter could be 0.501 provided it were perfectly square.

With geometry expressed as in Fig. 8 to 15, the geometry callout is to be held regardless of the size of the feature, and the feature size must be held regardless of any error in geometry. With geometry restricted to sizing zones, as in Fig. 1 to 7, the MMC concept is allowed in geometry. These examples are actually calling out 0.000 error at MMC.

When geometry is specified and consideration is being given to the MMC extension, it is necessary to investigate the expected function of the parts. Function determines original assignment of tolerance (size or geometry) and it also determines the application of MMC.

The function of the parts will occasionally reveal that geometry can be allowed to change, conditioned to sizing tolerance. Yet, the size itself must remain within the original specification. Sometimes feature size may be varied with geometry tighter than maximum allowed, but the geometry maximum must always be maintained. This means that there are three possible extensions under the MMC concept: 1. Geometry and size variation. 2. Geometry variation only. 3. Feature-size variation only.

The following three ways to specify MMC extensions on drawings should cover all possibilities:

GEOMETRY SPECIFIED IS FOR MAXIMUM MATERIAL CONDITION, GEOMETRY AND FEATURE SIZE MAY VARY.

When feature size is less than MMC, then geometry error may increase proportionately. When geometry is better than specified, then feature size may increase beyond MMC proportionately.

GEOMETRY SPECIFIED IS FOR MAXIMUM MATERIAL CONDITION. GEOMETRY MAY VARY.

When feature size is less than MMC, then geometry error may increase proportionately. Feature size must be held regardless of geometry error.

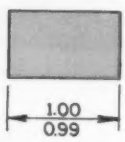
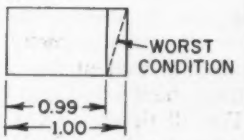
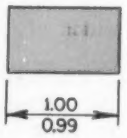
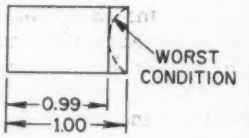
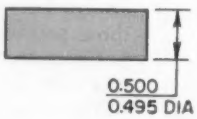
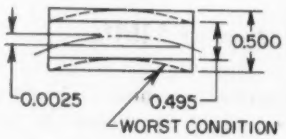
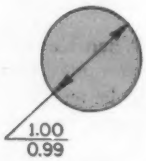
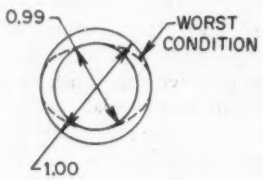
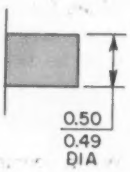
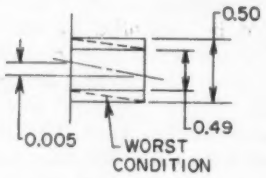
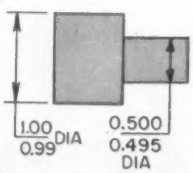
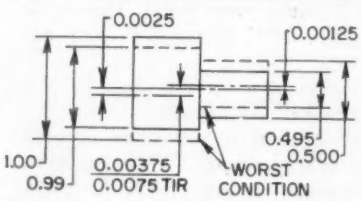
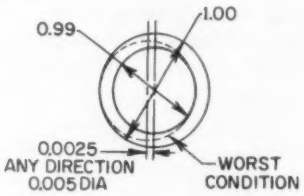
GEOMETRY SPECIFIED IS FOR MAXIMUM MATERIAL CONDITION. FEATURE SIZE MAY VARY.

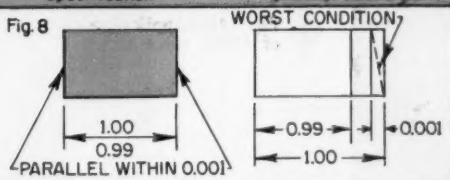
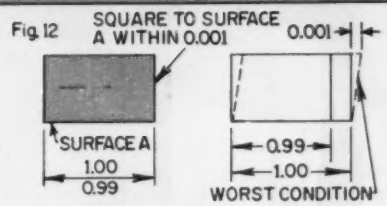
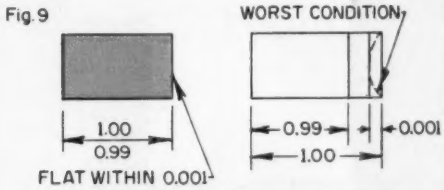
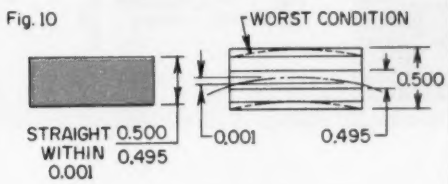
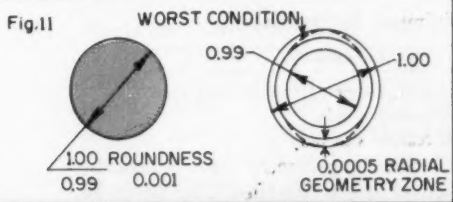
When geometry is better than specified, then feature size may increase beyond MMC proportionately. Geometry must be held regardless of feature size.

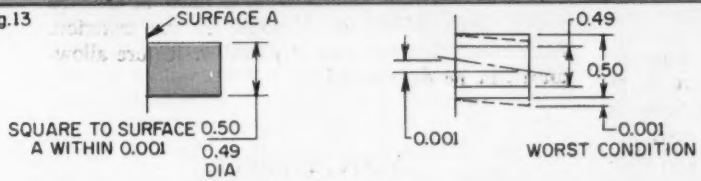
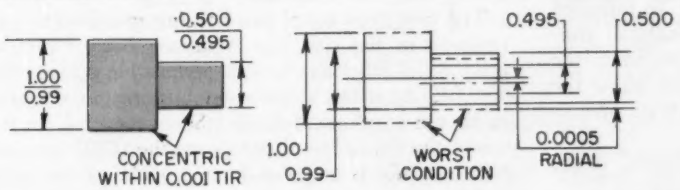
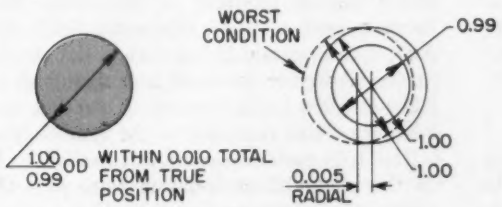
Currently, the custodians of MIL-STD-8 are in the

Parallelism
Flatness
Straightness
Roundness
Squareness
Concentricity
Location

Interpretations of Size and

Features	Features Unspecified		
	Specification	Interpretation	Max Error
Parallelism and/or Squareness of Flats	Fig. 1 		EQUAL TO SIZING TOLERANCE
Flatness	Fig. 2 		EQUAL TO SIZING TOLERANCE
Straightness	Fig. 3 		EQUAL TO HALF SIZING TOLERANCE
Roundness	Fig. 4 		EQUAL TO SIZING TOLERANCE
Squareness	Fig. 5 		EQUAL TO HALF SIZING TOLERANCE
Concentricity	Fig. 6 		TIR EQUAL TO HALF SIZING TOLERANCE (BOTH DIAMETERS)
Location	Fig. 7		DIAMETRAL MOVEMENT EQUAL TO HALF SIZING TOLERANCE

Features Specified					
All Geometry Inside Sizing Zone				Geometry Inside or Outside Sizing Zone	
Specification	Interpretation	Max Outline	Min Outline	Specification	Interpretation
Fig. 8 		MAX SIZE (1.00)	MIN SIZE (0.99)	Fig. 12 	
Fig. 9 		MAX SIZE (1.00)	MIN SIZE (0.99)		
Fig. 10 		MAX SIZE (0.500)	MIN SIZE (0.495)		
Fig. 11 		MAX SIZE (1.00)	MIN SIZE (0.99)		
				MEASURED PARALLEL TO SURFACE A= MAX SIZE (1.00) PLUS GEOM (0.001) = 1.001	MEASURED PARALLEL TO SURFACE A= MIN SIZE (0.99) MINUS GEOM (0.001) = 0.989

Geometry Inside or Outside Sizing Zone		Max Outline	Min Outline
Specification	Interpretation		
Fig. 13 		MEASURED PARALLEL TO SURFACE A= MAX SIZE (0.50) PLUS GEOM (0.001) = 0.501	MEASURED PARALLEL TO SURFACE A= MIN SIZE (0.49) MINUS GEOM (0.001) = 0.489
Fig. 14 		MAX SIZE (0.500) PLUS GEOMETRY (0.001) = 0.501	MIN SIZE (0.495) MINUS GEOMETRY (0.001) = 0.494
Fig. 15 		MAX SIZE (1.00) PLUS GEOMETRY (0.010) = 1.010	MIN SIZE (0.99) MINUS GEOMETRY (0.010) = 0.980

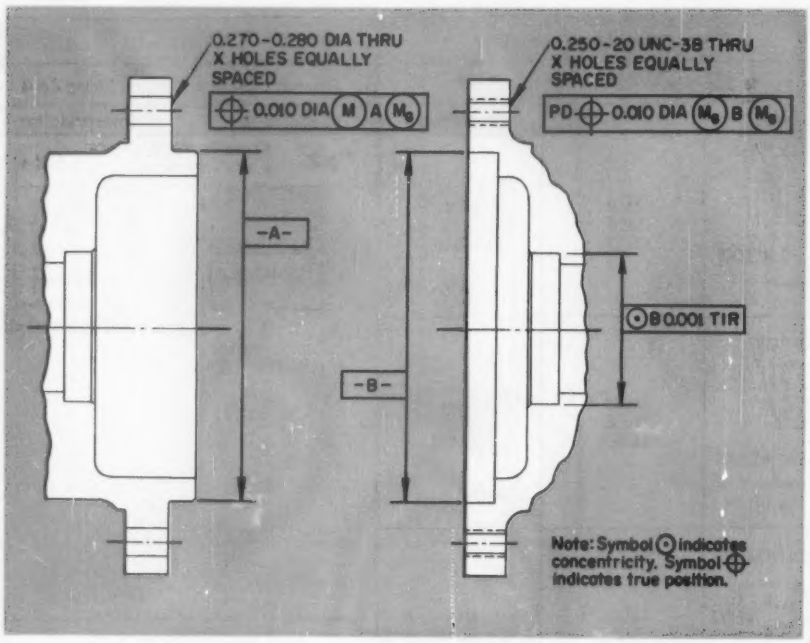


Fig. 16—Application of MMC concept.

Fig. 17—Application of MinMC concept.

process of determining symbols for applying MMC. Until the revision is published, the following may be adequate:

Symbols	Interpretation
M	Allows both geometry and feature size change
M_G	Allows geometry change only
M_F	Allows feature size change only

Usage of MinMC

Existing standards explain that the error in geometry is actually intended when the feature is at MMC. When this is true, the functional interest is ordinarily assembly of parts since the worst assembly condition is the part at its maximum material condition.

It is also true that the geometry may be intended when the feature is at its minimum material condition, MinMC. This would be the case when the functional interest is guarantee of stock since the worst stock condition would be the minimum material condition.

If the geometry is intended for MinMC only, these questions must be answered:

1. Can geometry error be allowed to increase proportional to the difference between actual finished size and MinMC? And, can feature size contain less stock than MinMC if location is better than the worst condition?
2. Can geometry alone be allowed to vary?
3. Can feature size alone be allowed to change?

Drawing notes to explain these allowances can be identical to those for MMC except for the substitution of minimum for maximum.

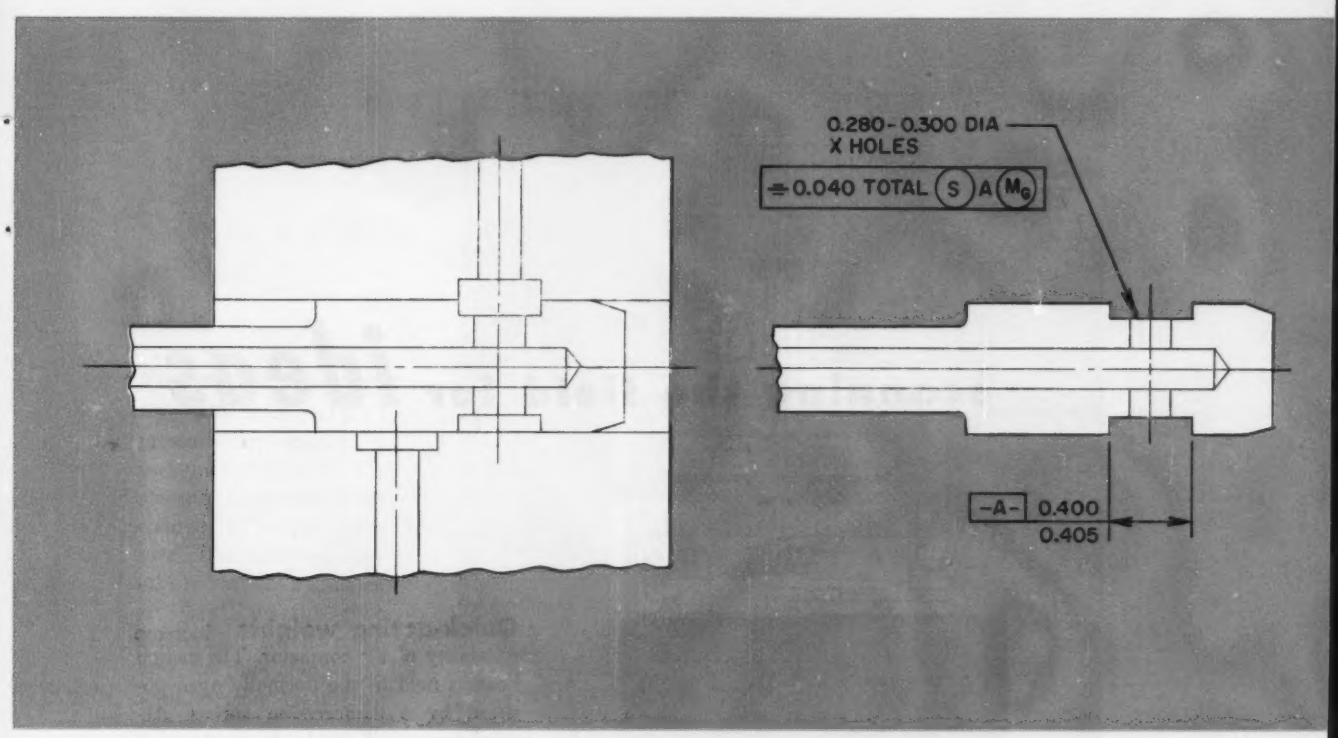
Symbols	Interpretation
S	Allows both geometry and size variation
S_G	Allows geometry only
S_F	Allows feature size only

In summary, when a geometry error which involves summation of size is specified, Fig. 12 to 15, it should be determined whether that error is intended for only one limit of the feature's size range. When this is functionally true, it must be decided which limit, MMC or MinMC, is the criterion. After this is known, geometry and/or feature allowance can be determined.

MMC Example

The part drawing of two housing members is represented in Fig. 16. The clearance holes for bolts use 0.270-0.280 holes with a permissible mislocation of 0.010 diameter, thereby establishing an effective minimum envelope of 0.260. Since the problem involves the fittability of the parts, the 0.010 location error actually is intended for the MMC of the hole, 0.270. If the hole is larger than 0.270, that increase can be extended to permissible mislocation (with a limit of 0.280 mislocated 0.020 diameter). Also, if the location is less than 0.010, the difference can be allowed to decreased hole size (with a limit of 0.260 at 0.000 location error). Therefore, the symbol following 0.010 diameter in the symbol block is M.

The true position system is specified to be based on the pilot OD or A-datum since it is the alignment feature between housings. If the datum diam-



eter is less than its MMC, its location can be allowed to shift by a proportional amount. Since the hole pattern is based on the pilot (effectively 0.000 location at MMC), there is no pilot location tolerance to save and changing pilot-diameter size is out of the question. Therefore, place the symbol M_G after the datum A in the symbol block.

In the mating part containing the tapped holes, a location of 0.010 diameter is used, giving an effective stock of 0.260 (maximum shaft plus 0.010). Since the minimum envelope of the hole is equal to the maximum envelope of the shaft, there is line-to-line fit at the worst assembly condition. Since the pitch diameter of the tapped hole is the actual feature being located, it is designated in the symbol block. If the pitch diameter is at its high side, that much extra mislocation can be extended since the larger pitch diameter allows more movement of bolt. The pitch diameter of ¼-20 UNC-3B is 0.2175-0.2211. The limit of geometry allowance, therefore, is 0.0136 for a 0.2211 PD. If the feature size is allowed to change at better than 0.010 location, the PD decreases to 0.2075 at 0.000 location. This cannot be allowed because the bolt would not fit in such a tapped hole. The class 3 fit between bolt and thread must be protected, and assembly of installed bolts to the mating part must be guaranteed. Choice of MMC allowance, therefore, must be M_G minus location ch nge only. Reference to the ID of the pilot or datum B follows exactly the reasoning of datum usage on the housing with clearance holes.

A specific concentricity between the bearing bore and pilot bore would be required regardless of the size of the bores, and the bores should be within their size range regardless of the eccentricity. Therefore, the concentricity error should be stated with no allowance for MMC concept.

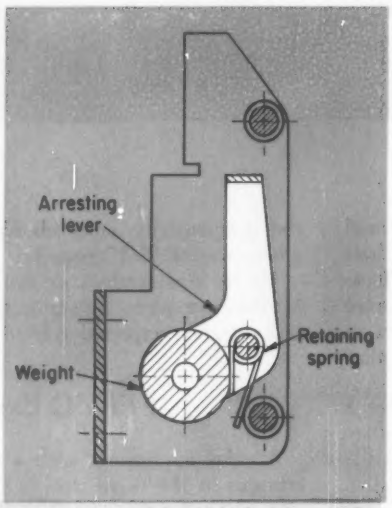
Unless the symbols or notes allowing MMC or MinMC extensions appear on the drawings, geometry and size are interpreted as fixed limits.

MinMC Example

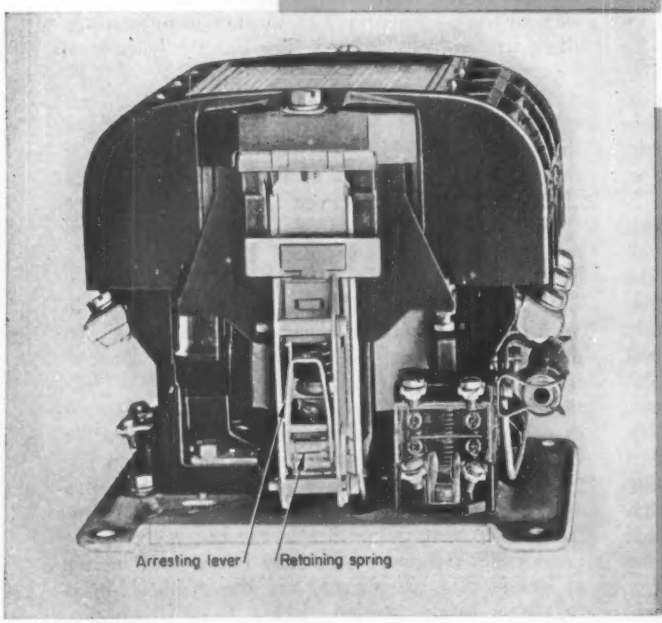
A valve application with a hole breaking into an annulus in the valve stem is shown in Fig. 17. The sides of the annulus actually do the porting and are, therefore, critically located. The holes only have to be contained within the annulus width.

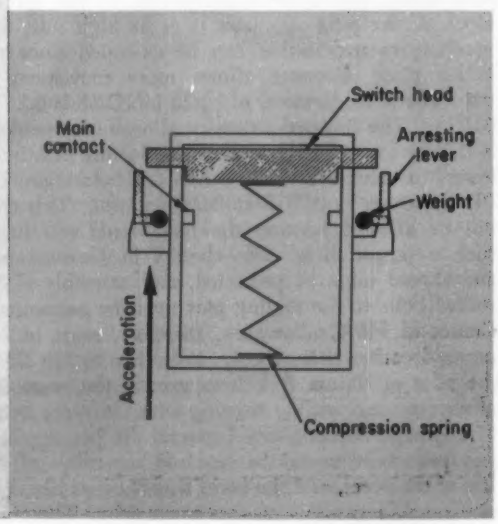
The detailed stem is shown with full tolerance extension, Fig. 17. The worst condition would be the largest hole, MinMC, or 0.300 located in the smallest annulus, MMC, or 0.400. Minimum stock of 0.030 is assumed between side of hole and edge of annulus. Then 0.040 total location tolerance can be issued at worst condition, $0.400 - 2(0.030) - 0.300$. Extra mislocation can be allowed if hole size is other than its MinMC (limit of 0.280 hole located within 0.060 total). Also, the hole can be allowed to increase in size if it is better located than 0.040 total (limit of 0.340 hole at 0.000 location). This establishes S after the location tolerance in the symbol block. If the annulus turns out to be 0.405, 0.005 extra can be issued to mislocation between hole and annulus. The size of the annulus cannot be allowed to change since its sizing in relation to its mating annulus in the housing must be guaranteed. Geometry only may be extended as far as datum A is concerned, and the symbol M_G is called for in the symbol block.

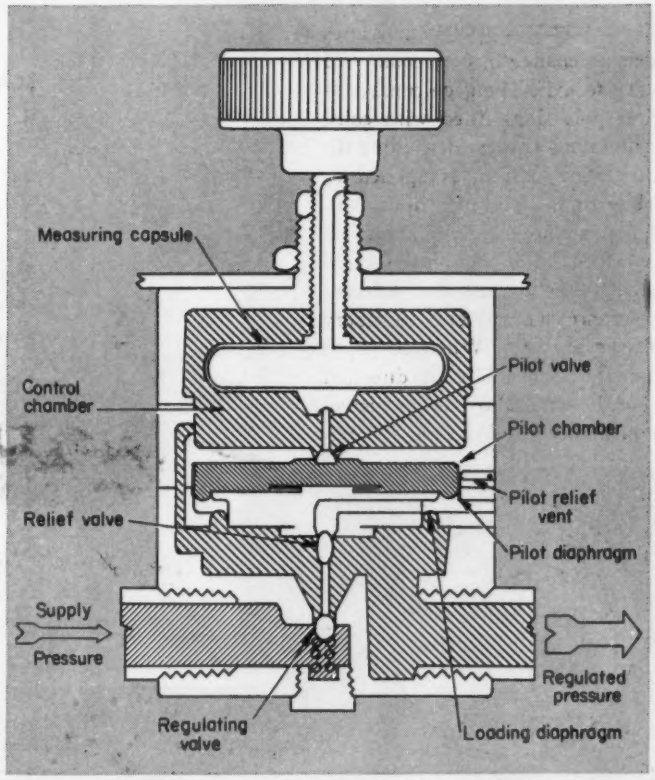
scanning the field for *ideas*



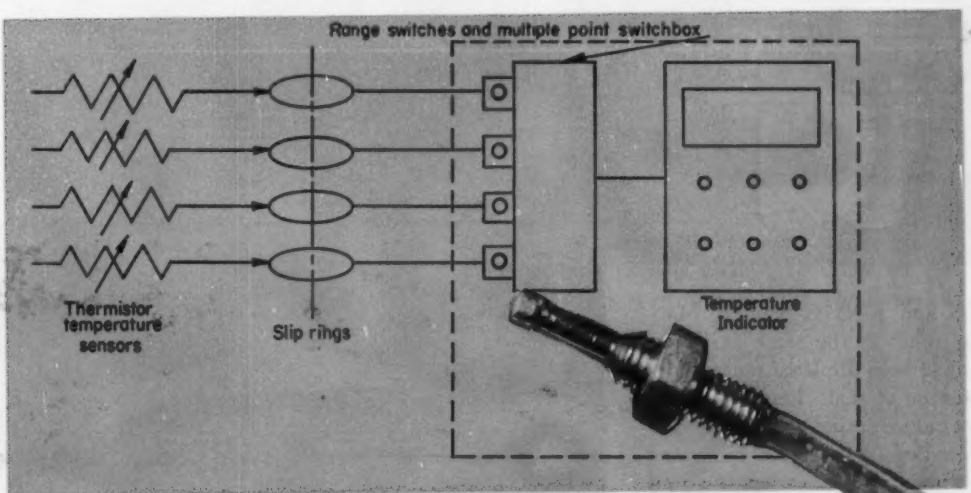
Quick-acting weights increase reliability of air contactor. The switch head is held in the normally open position by a compression spring. Acceleration or shock loads would tend to close the main contacts. However, same acceleration acts upon weights mounted on pivoted arms. Acceleration force rotates the weights inward, and arresting arms intercept the switch head. Shock protecting mechanism employed in air contactor developed by Allgemeine Electricitaets - Gesellschaft, Berlin, Germany.





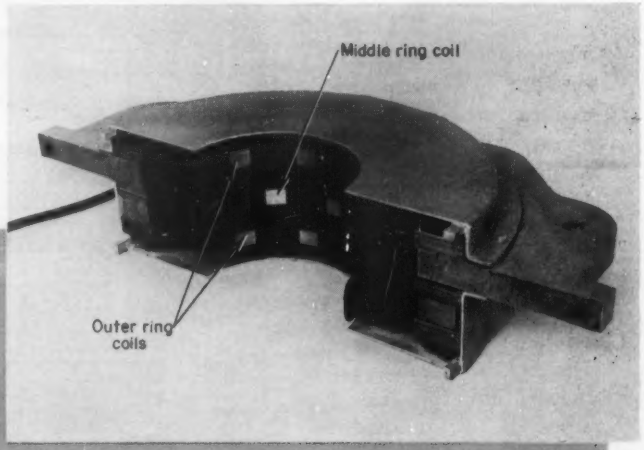


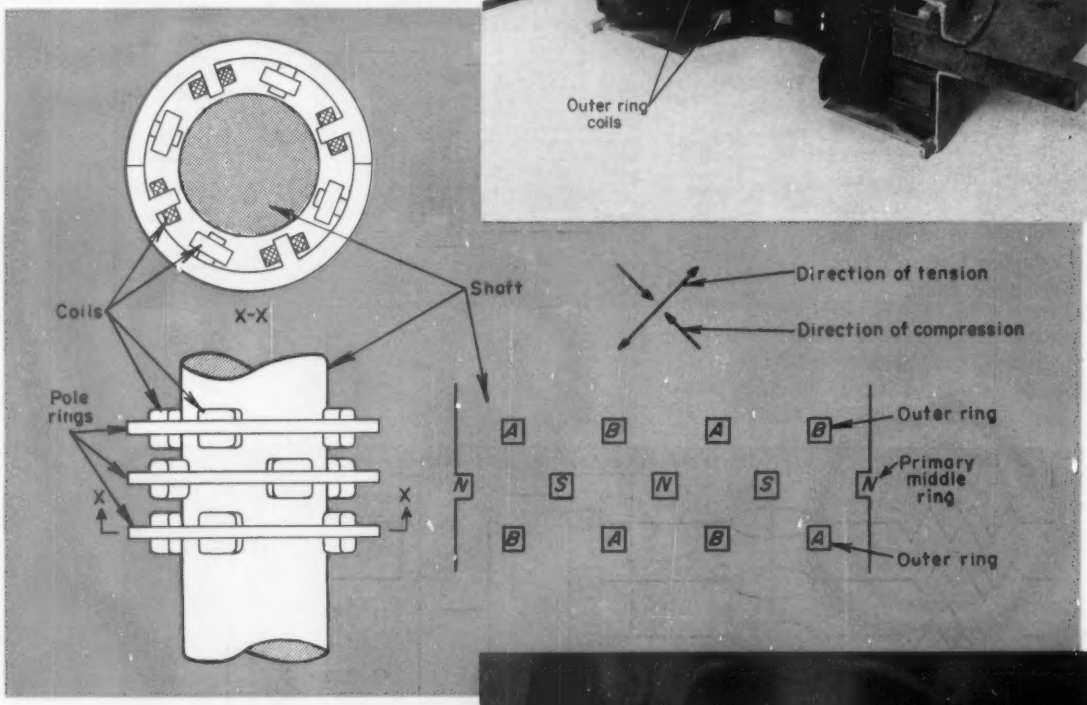
Pneumatic servo system uses output pressure to operate a pressure regulator. A measuring capsule senses changes in output pressure. The resulting capsule movement regulates air flow into the pilot pressure chamber. In turn, the pilot diaphragm actuates the regulating valve. Principle employed in air-pressure regulator developed by Lexington Controls Inc., Burlington, Mass.

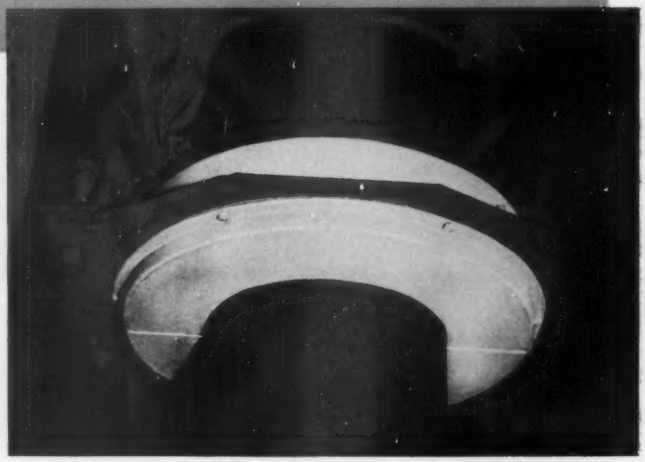


High temperature sensitivity provides sufficient output to permit use of slip rings in the lead circuit of a thermistor having an extreme temperature coefficient. This arrangement is possible because the resistance of the slip rings or relay is insignificant compared to the high resistance of the thermistor. Principle employed in temperature measuring device developed by Atkins Technical Inc., Cleveland.

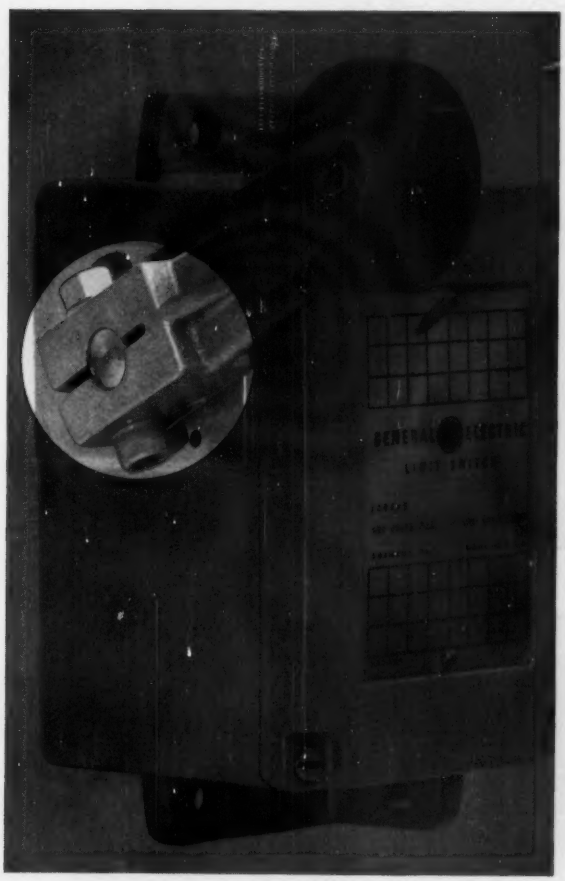
Ring-shaped torque gage measures torque by sensing change in permeability of shaft at 45 deg to axis. The gage consists of three identical pole rings fitted with coils, which have alternately reversed winding directions. Alternating current is applied to primary middle ring. Two outer rings, connected in series, are used as secondaries. If shaft is unloaded and without internal stresses, magnetic fields between different N and S-poles are symmetrical; secondary flux and voltage are zero. When torque is applied to shaft, permeability in direction of tension (A-N and B-S) is increased, whereas permeability in direction of compression (A-S and B-N) is reduced. Magnetically, the result is the same as if secondary rings had been displaced tangentially opposite to torsion of shaft. Resulting fluxes through poles induce output voltage in series-connected windings to control indicating instrument without amplification. As unit measures almost uniformly around shaft, 45 deg-stresses are virtually integrated around circumference. Measuring principle employed in torque gage manufactured by Allmanna Svenska Elektriska AB (ASEA), Vasteras, Sweden.

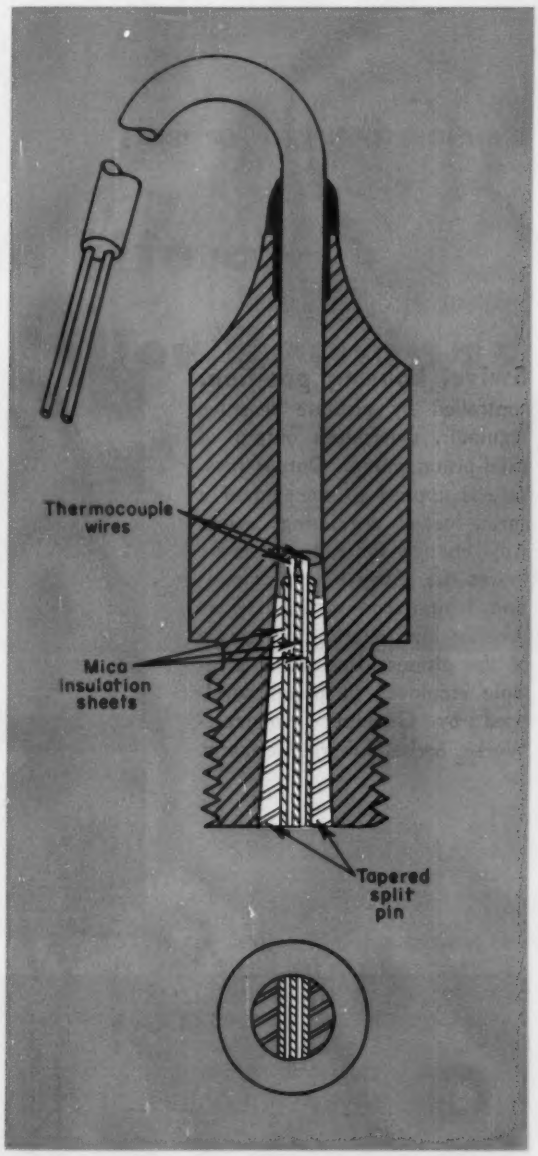






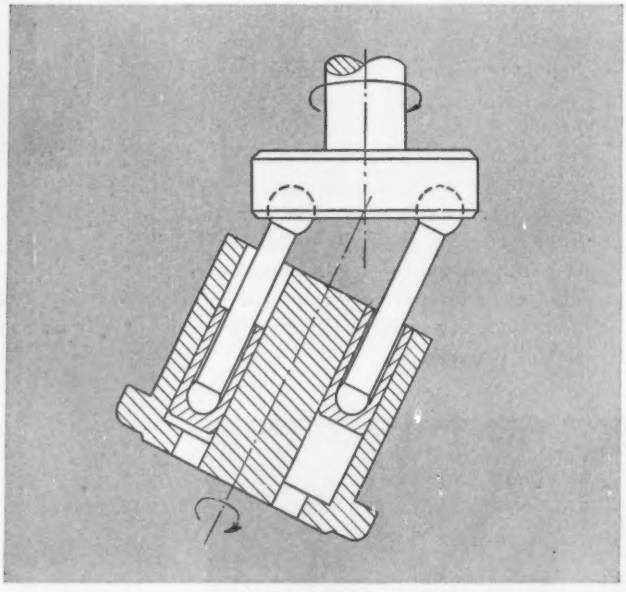
Worm-gear vernier adjustment of an operating arm relative to its shaft is provided by a capscrew and splined-shaft arrangement. The capscrew is free to rotate within the arm, but the threads engage longitudinal splines on the shaft. Thus, rotation of the capscrew provides vernier adjustment of the position of the arm. The arm is then clamped to the shaft by tightening a nut on the end of the capscrew. Adjustment arrangement employed in limit switch developed by General Electric Co., Roanoke, Va.

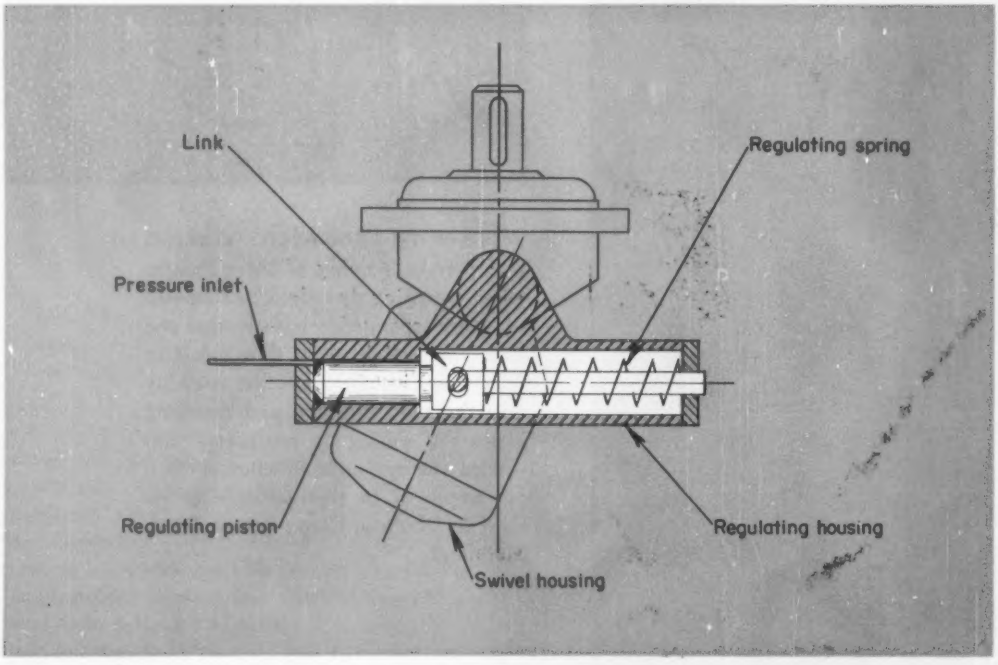




Mica-wire sandwich construction permits welding of thermocouple wires at sensing tip only. The flattened wires are separated from each other and from the well by very thin sheets of mica. After installation of the assembly into the well, grinding and polishing across the sensing tip produces a hot-welded thermocouple junction. Principle employed in thermocouple developed by Nanmac Corp., Indian Head, Maryland.

Swivel housing position, controlled by pressure sensitive regulator, determines output of axial-piston pump. Output pressure is applied to one end of a spring-loaded regulating piston. Any change in pump pressure moves the piston to a new position, thus repositioning swivel housing and altering the stroke of the pistons. Regulating principle employed in pump developed by Gueldner-Motoren-Werke, Aschaffenburg, Germany.





How to predict

Oscillation Life of Ball and Roller Bearings

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Cleveland, Ohio

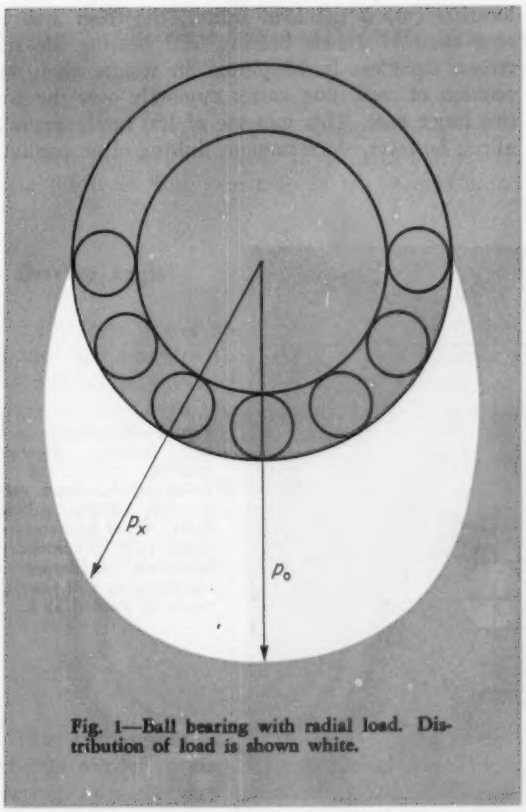

Fig. 1—Ball bearing with radial load. Distribution of load is shown white.

WHAT is the fatigue life of a bearing that oscillates? A practical way to estimate this value is to compare inner-race stressings of an oscillating bearing with those of the same bearing used in a rotating application. Here, a method is presented and applied that establishes ratios of oscillation ratings and rotation ratings. Rotation ratings used are standard B10 ratings, as given in bearing catalogs in terms of number of revolutions (or hours at a given constant speed) that 90 per cent of a group of bearings will complete or exceed before the first evidence of fatigue develops.

Ball Bearings—Radial Load

For the most common case of moderate oscillating travel and radial load, the heaviest-loaded ball receives *two* stressings during each complete oscillation. Under continuous rotation, each point on the inner race receives $n[1 + (d/p)]/2$ or $nH/2$ stressings per revolution. As usual, life is determined by corresponding stresses on the inner race.

In a radially loaded bearing, these stressings vary in value as they are transmitted to the inner race, and an equivalent constant load per ball must be determined. Load per ball varies generally as shown in Fig. 1, where p_0 = load on the bottom ball and δ_0 = deflection of that ball. Deflection δ_x of any ball

is

$$\delta_x = \delta_0 \cos \alpha$$

where α = angle between that ball and the heaviest loaded ball. Load p_x, due to external load P is

$$p_x = p_0 (\cos \alpha)^{2/3}$$

Since ball-bearing life varies with $(1/P)^3$, equivalent constant load p_e is

$$p_e = \frac{2}{\pi} p_0 \left[\int_0^{\pi/2} (\cos \alpha)^2 \, d\alpha \right]^{1/3}$$

from which, $p_e = 0.794\ p_0$.

The oscillation-versus-rotation ratio of stressings per revolution under radial load, with allowance for the upper half of the bearing being free, is

$$\frac{2}{\frac{1}{2}\left(\frac{nH}{2}\right)} \text{ or } \frac{8}{nH}$$

Nomenclature

D_i = Inner-race diameter, in.
D_o = Outer-race diameter, in.
d = Ball or roller diameter, in.
$H = 1 + (d/p) = D_o/p$ (See footnote)
$J = 1 - (d/p) = D_i/p$ (See footnote)
n = Number of balls or rollers
P = External bearing load, lb
p = Pitch diameter, in.
p_e = Equivalent constant load per ball or roller, lb
p_0 = Load on heaviest-loaded ball or roller, lb
R_R = Bearing-rating ratio (oscillating to rotating) for radial load
R_T = Bearing-rating ratio (oscillation to rotating) for thrust load
δ_0 = Deflection on bottom ball or roller, in.
θ = Overlap angle, deg

For angular-contact bearings, the effective race diameter (actual ball-contact diameter) is used.

Combining this with the equivalent constant load and applying the inverse-cube relation give the ratio, R_R, of oscillating-versus-rotating service under radial load as

$$R_R = 0.794 \left(\frac{nH}{8}\right)^{1/3} = 0.40 (nH)^{1/3} \qquad (1)$$

Ball Bearings—Thrust Load

Under a thrust load, all balls are stressed equally. The ratio of oscillating-to-rotating stressings becomes

$$\frac{2}{\frac{nH}{2}} \text{ or } \frac{4}{nH}$$

Applying the inverse-cube relation gives the ratio, R_T, of oscillating-versus-rotating rating under thrust load as

$$R_T = 0.63 (nH)^{1/3} \qquad (2)$$

Equations 1 and 2 assume: 1. The oscillation occurs repeatedly over the same arc. 2. The arc of oscillation is not large enough so that the path of one ball on the inner race overlaps that of the next.

Varying Travel

If the ball path on the inner race shifts to a new location (or, if the load shifts), the fresh area is equivalent to a new bearing, and bearing life increases significantly. Maximum life results when the position of oscillation varies randomly over the entire inner race. This increase of life rarely materializes, however, since random shifting of an oscillat-

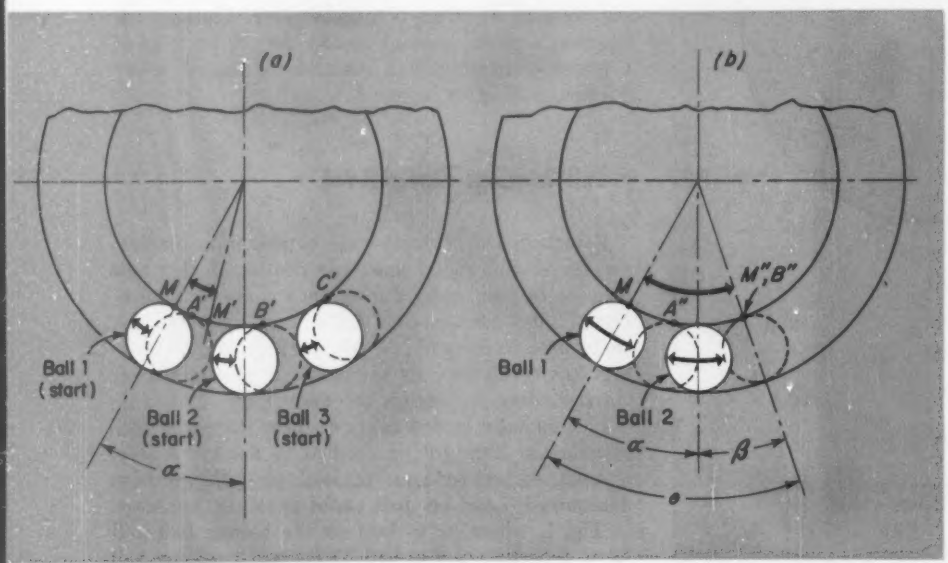

Fig. 2—Oscillation in a ball bearing, showing relative motion of a point on the inner race to that of the rolling balls. Inner race rotates; outer race is stationary. Moderate oscillation is shown at *a;* full overlap angle is reached at *b*.

Design Example

Problem: Select a ball bearing for the flapping axis (inner race rotating) of a helicopter blade. Design conditions: Radial load, P = 1400 lb; oscillations per min = 300; oscillating travel = 12 deg; shaft size = 1.3780 in.; desired life (B10) = 1950 hr.

Solution: For trial, select several bearings in the size and general load area (see below). List physical data and rotational ratings and calculate H for each bearing. Since pitch diameter usually is not known, the approximation of p = (Bore + OD)/2 can be used. For the H values listed below, Fig. 3 shows that overlap would not occur at 12 deg unless the bearings had more than 35 balls per row.

Knowing H and n, select values of R_R from the "no overlap" curve of Fig. 4. Multiply rotating-load rating by R_R to get oscillation-load rating.

Calculate B10 oscillation life as

$$500 \left(\frac{\text{Oscillation-load rating}}{p} \right)^3$$

Of the bearings selected, either of the counterbore type No. 207 or two No. 106 fulfills the design requirements.

	Bearings Selected				
	—Conrad Type—		—Counterbore Type—		
Size	107	207	107	207	(Two) 106
Bore (in.)	1.3780	1.3780	1.3780	1.3780	1.1811
OD (in.)	2.4409	2.8346	2.4409	2.8346	2.1654
Width (in.)	0.551	0.669	0.551	0.669	2 × 0.512
Balls, n (typical)	11	9	14	14	14
Ball dia, d (typical) (in.)	5/16	7/16	5/16	3/8	9/32
Load rating, rotating B10; 300 rpm, 500 hr (lb)	1330	2130	1570	2180	2470 (1.9 × 1300)
$H = 1 + (d/p)$	1.16	1.21	1.16	1.18	1.17
Overlap angle, θ (deg) from Fig. 3	56	67	44	44	44
Ratio, R_R, from Fig. 4	0.95	0.89	1.01	1.01	1.01
Oscillation-load rating (lb)	1263	1896	1586	2202	2495
Osc. rating/P	0.90	1.36	1.13	1.58	1.78
Estimated B10 life (hr)	365	1260	722	1970	2820

ing angle is uncommon. Also, when bearing races are even slightly "pocketed" in a particular travel area, the balls tend to remain in the worked area.

Overlap Angle

For large travel angles, the path on the race of one ball overlaps the next ball path, doubling the number of stressings. This overlap angle is the angle traveled by a given point on the inner race from its contact with one ball or roller to its contact with the next ball or roller. Fig. 2*a* shows the motion of point M on the inner race. As M moves to M', ball 1 moves to A' and ball 2 to B'. Overlap occurs when M reaches M'', Fig. 2*b*, where it contacts ball 2, in Position B''.

Angle of overlap θ is the sum of angles α and β and is given by

$$\theta = \frac{720}{nH} \qquad (3)$$

This relationship is plotted, Fig. 3, for direct solution of overlap angle. Since the value of H for bearings does not vary appreciably, Equation 3 can

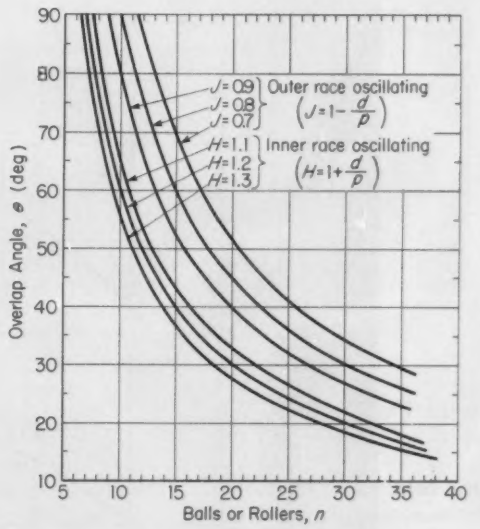

Fig. 3—Overlap angle versus number of balls or rollers for various values of H and J.

be reduced to $\theta = 600/n$, using the mean value of $H = 1.2$.

When single overlap occurs, the maximum-stressed points on the race have four stressings per oscillation instead of two. For radial load, the second pair of stresses is smaller, in the ratio of $\cos^{2/3}$, and the capacity is reduced by the ratio of

$$\left(\frac{1}{1 + \cos^2} \right)^{1/3}$$

and Equation 1 becomes

$$R_R = 0.40 \left(\frac{nH}{1 + \cos^2 \theta} \right)^{1/3} \quad (1a)$$

For a thrust load, the capacity drops in inverse-cube relation, and Equation 2 becomes

$$R_T = 0.50(nH)^{1/3} \quad (2a)$$

Calculations using these formulas, for standard bearing proportions, show very little variation from type to type. Using the average value of $H = 1.2$ affords not over 2 per cent error for the capacity ratios and not over 5 per cent for overlap angle. On this basis, Fig. 4 summarizes the results so that one set of curves permits complete solution.

With greater angles of oscillation, reaching double or triple overlap, the action approaches pure rotation, and standard rotational bearing-life ratings can be used, with one important modification: There are twice as many stressings per complete oscillation compared to stressings per complete rotation, and the rotational ratings should be divided by $2^{1/3}$, or 1.26.

Outer-race oscillation produces the same two stressings per cycle, and the same equations and curves (Fig. 4) apply, still using inner-race-rotation ratings. However, the overlap angle changes to

$$\theta = \frac{720}{nJ} \quad (3a)$$

where J is the ratio of inner-race diameter to pitch diameter. Equation 3*a* is also plotted in Fig. 3.

Roller Bearings

Equations for roller bearings differ from ball bearing equations for several reasons: 1. Life varies with $P^{0.3}$, not $P^{1/3}$. 2. Equating the radial ratings to a constant roller loading involves a different distribution pattern. The smaller deflections and greater loosenesses change load distribution so that fewer rollers carry the load—nearer $1/3$ than $1/2$. 3. Measured deflections* exceed Hertz-theory calculations by five to ten times, the ratio varying with bearing quality and load intensity.

The effect of these empirical deflection equations is to change Equations 1 and 2, for roller-bearing applications, to

$$R_R = 0.40(nH)^{0.3} \quad (1b)$$

$$R_T = 0.66(nH)^{0.3} \quad (2b)$$

These are so close to the ball-bearing formulas that the curves of Fig. 4 can be used for approximation.

*Arvid Palmgren—*Ball and Roller-Bearing Engineering*, SKF Industries Inc., Philadelphia, 1945, p. 47.

AUTHOR'S NOTE

Formulas for oscillating loads on ball bearings, similar to those in this article, have been derived independently by A. B. Jones, Fafnir Bearing Co., New Britain, Conn.

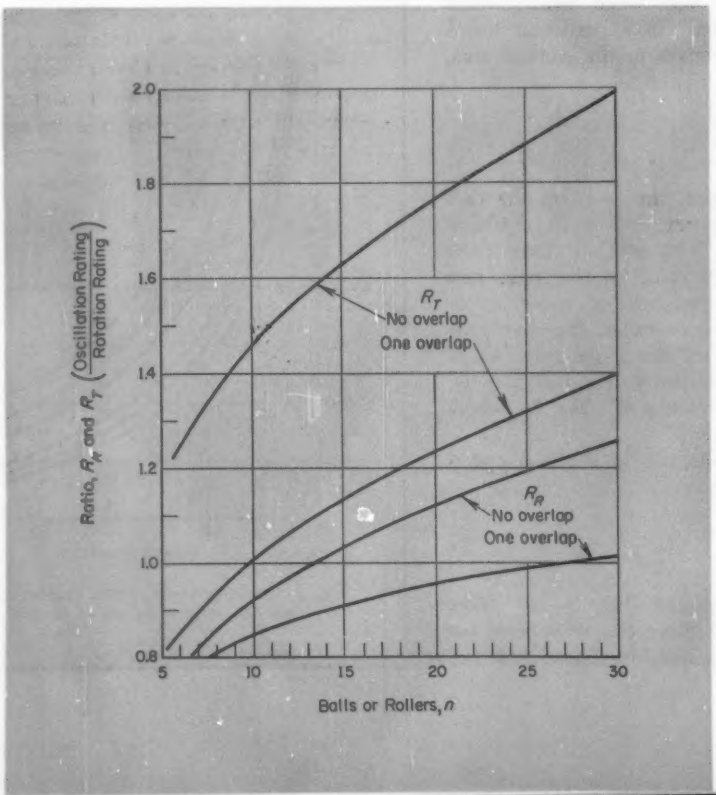

Fig. 4—Ratios of oscillating capacity to rotating capacity for radial and thrust loads on ball bearings. Curves based on mean value of $H = 1.2$.

Designing Steel Liners

for Light-Metal Housings

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STEEL parts—bearings or seals, for example—installed in aluminum or magnesium housings of equipment that operates at temperatures appreciably above assembly temperature, require interference-fit steel liners. Without liners, the housings open up due to their greater thermal expansion, and can cause serious damage or malfunction of the equipment.

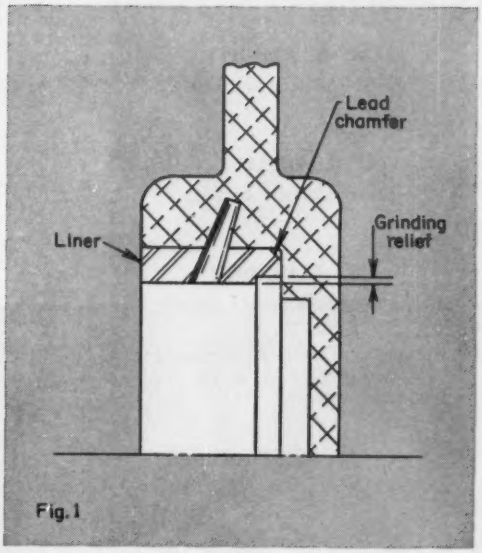

Fig. 1

Design: The liner construction of Fig. 1 allows shims to be assembled between the bearing and the housing shoulder. Axial positioning of the liner is obtained as it bottoms against the machined shoulder of the housing. A grinding relief 0.015 to 0.020 in. deep by 0.060 in. long facilitates final grinding of the inner wall of the liner without requiring precise depth control.

An alternate liner construction is shown in Fig. 2. For this configuration, an assembly tool that bottoms against the housing shoulder is required to ensure axial alignment. Liners of both types have chamfered leading edges that guide them into the bores and prevent their shearing metal from the housing walls in assembly. A wall thickness of 0.060 in. is practical for liners up to 7 in. diam.

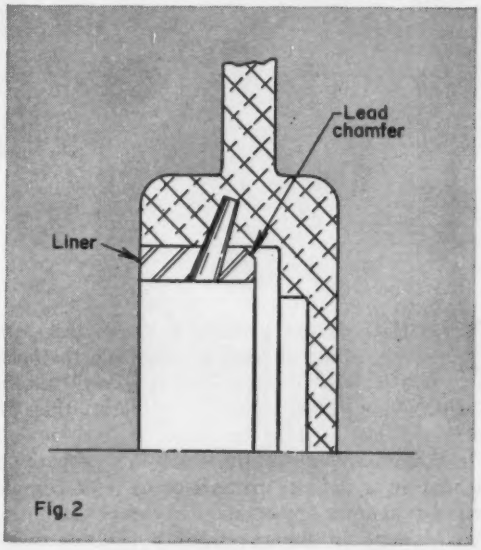

Fig. 2

Materials: A cold-finished seamless-steel tubing of AISI 4130 with maximum hardness of Rockwell C25 is recommended for liner construction.

Liners are frequently cadmium plated for corrosion protection in stock, and for protection against dissimilar-metals contact in use.

Fastening: Two taper pins at 180 degrees are adequate to fasten liners of Fig. 1 construction having diameters to 1.5 in. At least three pins should be used to secure liners of Fig. 2 design. A general rule for either construction is to use three pins up to 1.5-in. diam, and one pin per inch of diameter increase above 1.5 in.

Taper pins are assembled in blind reamed holes to avoid breaking through to the outside of housings.

Assembly: Maximum recommended interference fits between liners and housings are: 0.001 in. per in. plus 0.0005 in. up to 2 in. diam; 0.001 in. per in. plus 0.001 in. from 2 to 5 in. diam; 0.001 in. per in. plus 0.002 in. over 5 in. diam.

Prior to assembly, liners should be coated with zinc-chromate primer or paste to facilitate assembly and to provide additional dissimilar-metals contact protection. Liners are then cooled in dry ice to −40 F, and housings are heated to a maximum of 300 F for assembly.

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How to select and apply

TIMERS

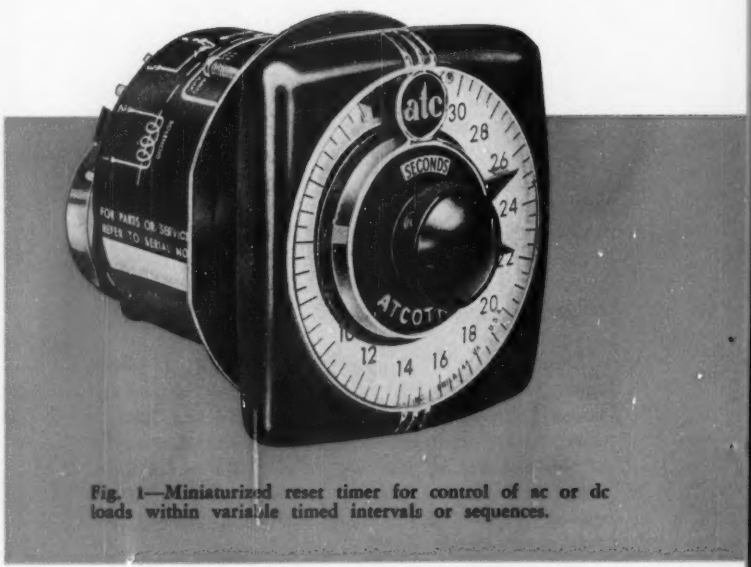


Fig. 1—Miniaturized reset timer for control of ac or dc loads within variable timed intervals or sequences.

TIMING devices perform a simple task—they introduce the element of time into the operation of other devices. Timers control the time at which some action starts or stops. Also, they control the length of time the action is "on" or "off."

If these basic timer functions are properly sequenced in a definite pattern or cycle, a complete control system for any component can be established. The ultimate in timer versatility is demonstrated when any number of components, machine functions, or processing operations are combined and controlled by a master timing system.

Although the most common application of timers is in the control of such components as motors, valves, solenoids, heating elements, lamps, and relays, timers are also used as safety devices. In addition to sounding an alarm when certain machine or process functions fail to take place within a predetermined time, a timer may be used to shut down the system until the trouble is remedied.

In the application of timers, new terms or expressions have developed that are unfamiliar outside a particular company or local area. Some common but ambiguous terms for different timer types are: Time clock, time switch, clock-operated switch, cycle controller. Terminology commonly accepted on an industry-wide basis is used and defined here as an aid to the designer. In addition, timer operation, features, functions, and types are discussed along with other factors normally considered in timer selection.

General Classifications

Timers are classified as either repeat cycle or stop cycle. A repeat-cycle timer runs through one cycle upon closure of the starting contact and repeats this cycle until power is interrupted. When power interruption occurs, the timer stops; when power returns, the timer continues the cycle from the point of interruption. Repeat-cycle timers have no definite starting or stopping point in the cycle.

A stop-cycle timer, however, has a definite starting and stopping point. Upon closure of the start

...for CONTROL of components, machines, processes ...for SAFETY when functions fail to occur on time

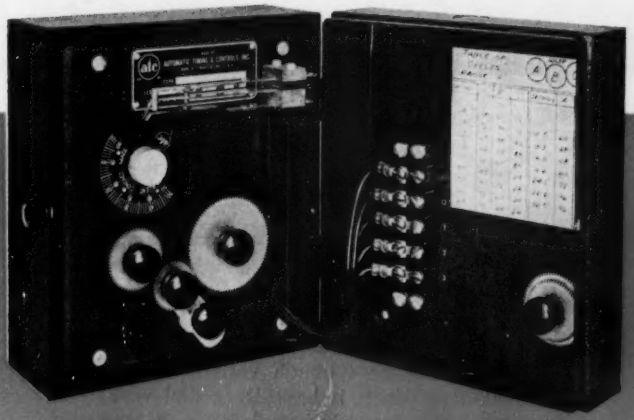
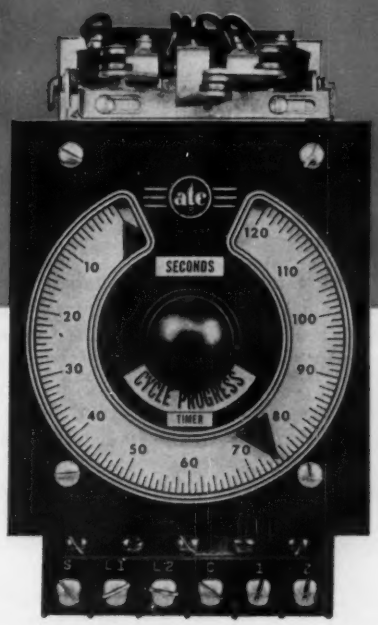


Fig. 2—Adjustable split-cam timer. Extra gears provide additional adjustment by changing over-all cycle time.

Fig. 3—Heavy-duty cycle-progress timer which instantly resets to zero when power supply is interrupted.



contact, the timer travels through one cycle and stops.

Reset and Nonreset Types: A "reset" timer returns to its before-start status if, during its cycle, power is removed either by failure or on command. At the end of its cycle it may remain in a timed-out position awaiting command to reset; or, it may automatically reset to before-start status.

A "non-reset" timer does not return to before-start status upon either power failure or intentional power removal during or at the end of its timing cycle. It stops when power is removed and resumes its cycle from that point automatically when power returns or, if so arranged, awaits a command to resume cycle. At end of cycle it requires a command to reset to before-start status.

Manner of Setting

Dial: Units designed for dial adjustment have a fixed, complete time cycle and a hand-adjustable knob, Fig. 1. Turning the knob either sets a pointer to a portion of the dial or moves the dial to a stationary index point. This setting determines the total time cycle for successive cycles until dial setting is again manually changed. On some lower-cost devices this setting must be made to start each cycle.

Increment: The position for contact actuation is usually set by means of clips or pins attached to a large dial or disc with suitable notches or divisions. This method permits selection of fixed points throughout the cycle for load action control.

Cam: Timers having either a solid cam with fixed

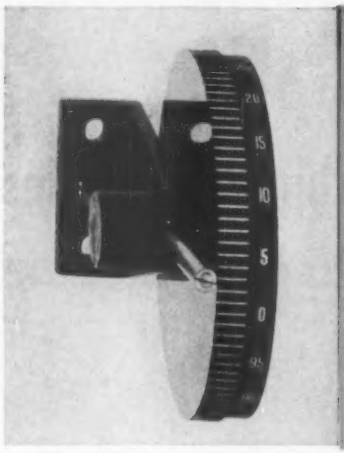


Fig. 4 — Calibrated timer disc with scale markings on disc circumference.

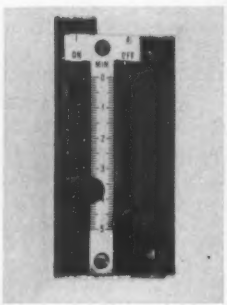


Fig. 5—Flat scale for vertical reading and setting of timer operating points.

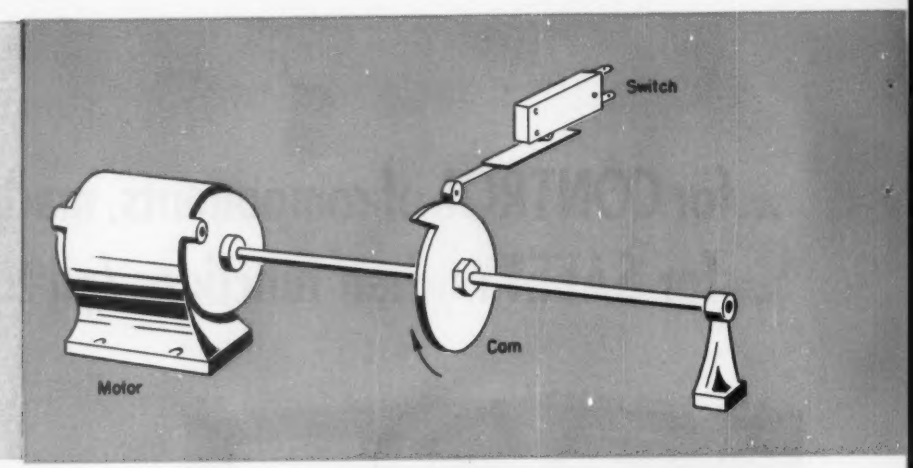


Fig. 6—Simplified representation of electromechanical timer.

cuts or a split cam with adjustable halves, Fig. 2, are available. The split cam permits variation of the contact closure time. Both styles are usually adjustable with respect to the starting point of a cycle.

Uncalibrated: Although there is no accurate dial or scale for reference, the basic time cycle may be changed. Some units have absolutely no indication, and all settings must be accomplished entirely by trial and error. When accurate settings are required, a stop watch is often used.

Indication

Dial: Usually calibrated, the dial may have a pointer which moves with respect to it, or the dial itself may rotate past a fixed index for setting. The dial may also show cycle progress, Fig. 3. In this case, depending upon the timer cycle, timing may progress from zero to a predetermined setting or from the predetermined setting to the dial zero.

Calibrated Disc: While this type is similar to the dial type, the exception is that the disc, Fig. 4, usually includes a means of operating a low-voltage contact through cuts on the periphery of the disc or through actuating pins attached to it.

Scale: Actually a linear dial, this type of indicator has scale markings on one continuous straight-line surface rather than around a periphery. The scale may be located for either vertical or horizontal readability, Fig. 5.

Many variations of these three basic types of indication exist. One common variation is a digital read-out dial, which is basically a dial with numbers printed on its periphery. It gives a direct read-out value rather than an interpretation of the normal dial subdivision value.

Starting Method

Sustained Start: With a repeat-cycle timer, the sustained-start contact remains closed during entire first and successive cycles; opening the contact stops the timer at that point. Applied to a stop-cycle timer, the sustained-start contact remains closed during and after completion of the timed cycle and opens only when de-energized, which allows the timer to reset.

Momentary Start: In this case, brief closure of a pushbutton, limit switch, or other contact initiates timer operation. The timer has its own maintaining circuit which permits it to complete its pattern even though the starting contact is reopened. This type of operation can be used for instant lockup of a timer or for holding the start circuit closed for a specific minimum time.

Operating Principle

Electromechanical: Most timers fall into this category. "Electromechanical" refers to a timing unit operated by: An electric motor, Fig. 6; motor plus an electric clutch, Fig. 7; an electric-clutch mechanism plus a spring motor; an electric clutch plus a dashpot-drive mechanism; or any other combination of components that are either entirely or partially electrically operated.

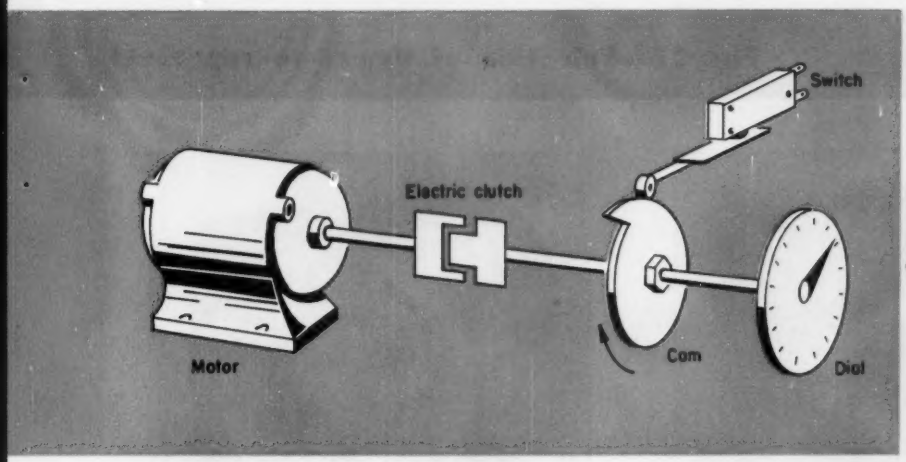


Fig. 7— Electromechanical timer using an electric-clutch drive.

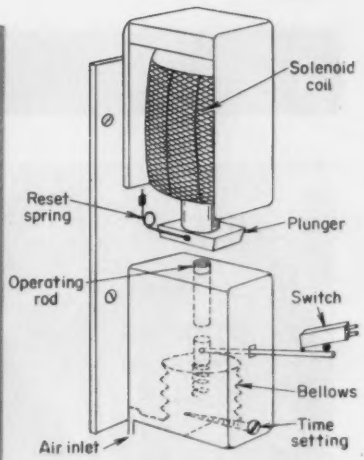


Fig. 8—Pneumatic timer which can provide either "on" delay or "off" delay for the load circuit.

Pneumatic: Actually an electromechanical type, these units have a pneumatic means that provides timing. The unit is usually energized by an electrical device or through an electric clutch, and timing is controlled by the rate of air leakage through a control orifice, Fig. 8 and 9. The system allows an arm or plate, cocked by the drive mechanism, to return to its start position after operating the load contacts.

Electronic: Electronic timers use the controlled charge or discharge rate of a capacitor through a resistance, Fig. 10. The capacitor usually controls the bias voltage on a tube or transistor which triggers a relay when a preset timing increment is reached. These timers are ordinarily used for short intervals ranging from split seconds up to a maximum of 150 sec. However, in some applications where accuracy is not too critical, the timing range may be extended to as long as 10 min.

Mechanical: These timers have neither an electric drive motor nor a clutch. Drive power is provided by a dashpot or drive spring, Fig. 11, with some form of escapement regulator to give fairly good timing accuracy.

Thermal: This type operates by passing current through a bimetallic strip, causing it to bend. An adjustable contact controls the gap to be closed or opened by the bending of the strip. The gap controls the delay time.

Accuracy

Setting: A statement of setting accuracy is usually given as a percentage of the timer's full time cycle and is a plus and minus tolerance unless specifically stated otherwise. Even though not stated, setting

(*Text continued on Page* 126)

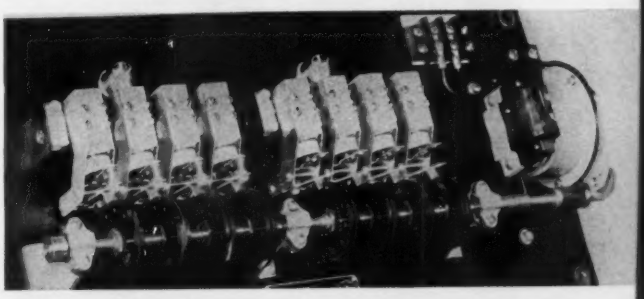


Fig. 9—Sophisticated pneumatic timer with an assembly of poppet valves and split-adjustable cams for operating several pneumatic controls. This type of timer is suitable for operations in hazardous areas where air control is mandatory.

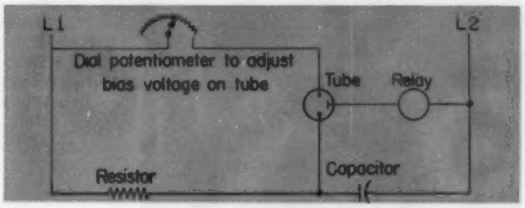


Fig. 10—Circuit diagram for electronic timer. Resistor-capacitor combination builds up voltage on thyratron tube until it fires, thus operating the load relay contacts.

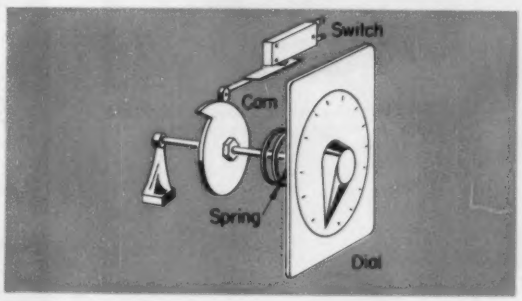
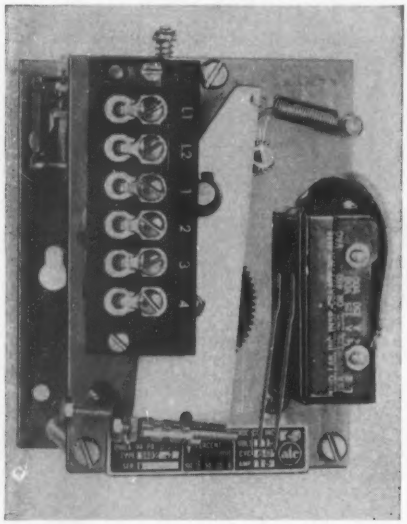
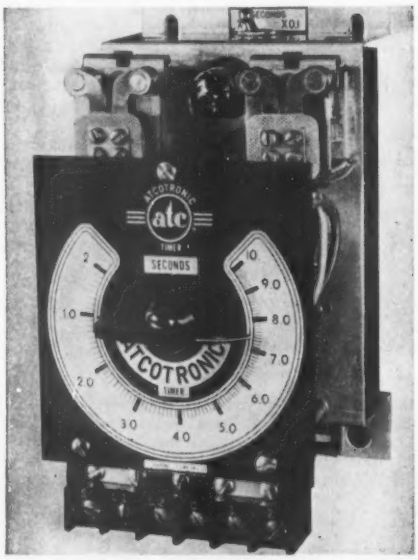


Fig. 11—Mechanical spring-driven timer. Knob is turned to desired dial setting and automatically winds spring which powers the timer through an escapement regulator.

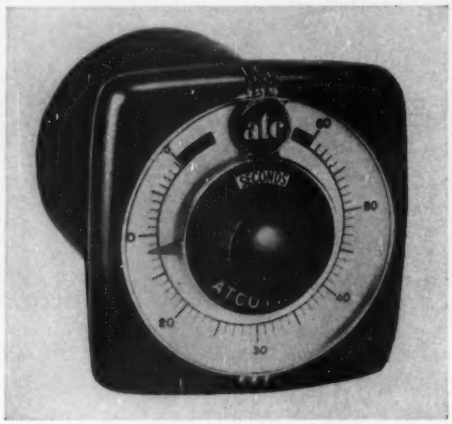
Fig. 12—Selection of timers to represent



a—Reset delay timer with screw-adjustable time periods. Electromagnetic coil provides instant reset by positive clutching and declutching of a trip-locking gear.

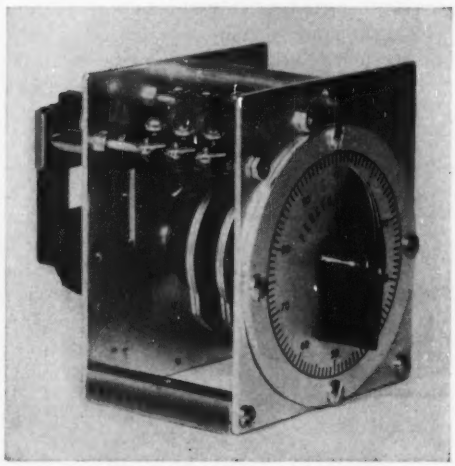


b—Electronic timer using a thyratron tube to trigger the load relays.

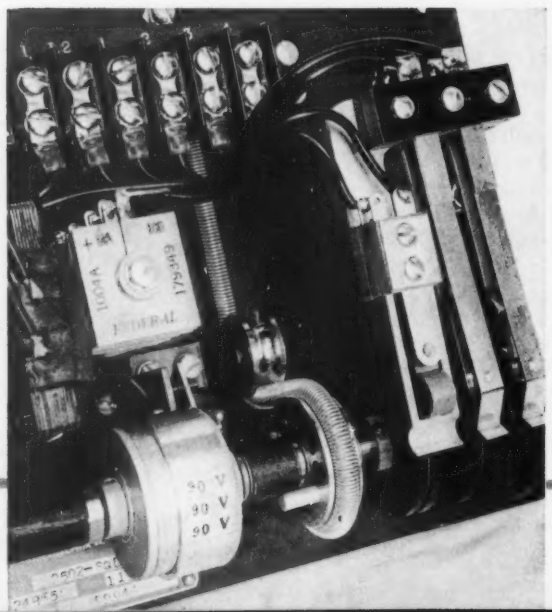


c—Transistor timer for simplicity and maximum life. Filtered power supply feeds an RC network through a transistor to operate a relay at end of timing cycle.

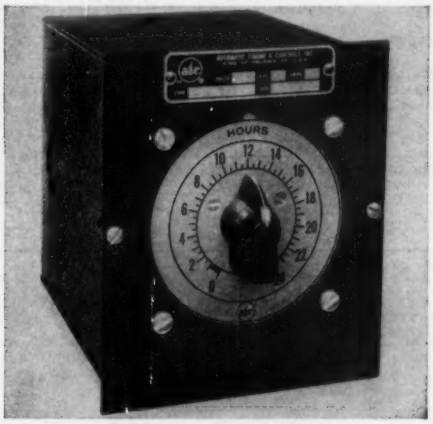
d—Multicircuit cam timer with overriding motor clutch to permit cycle change whether timer is operating or not.



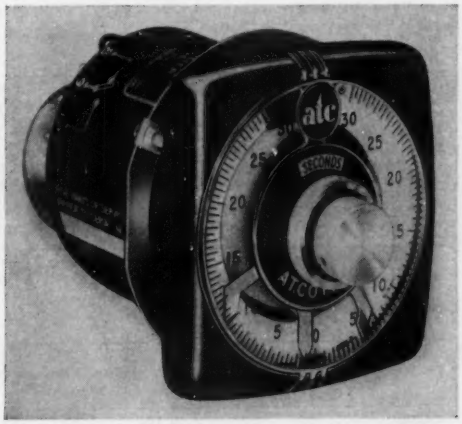
e—Reset cam timer for instant resetting if power fails. Built-in dc power source operates a magnetic clutch. When power returns, timer can start automatically or await a signal.



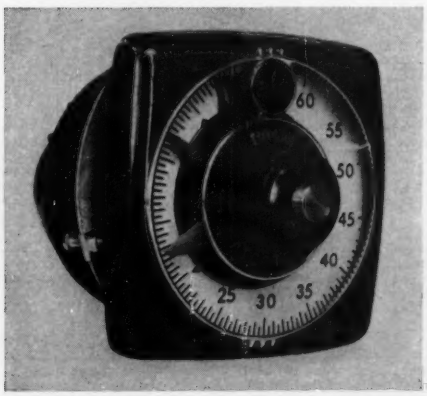
basic types referenced in Table 1.



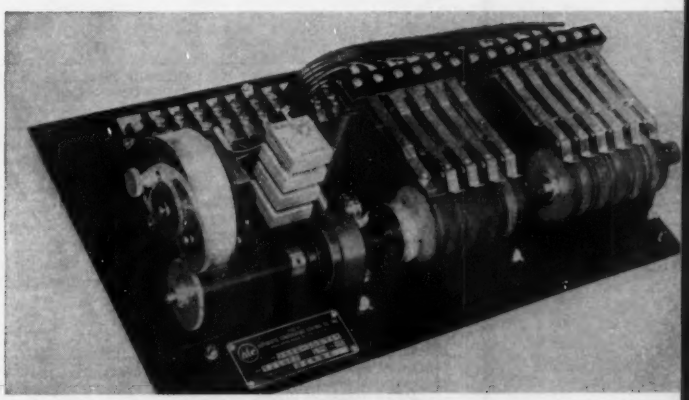
f—Inexpensive manual-start timer for switching load current "on" or "off" after selected time period. Pointer indicates time remaining in cycle.



i—Miniature dual-function repeat-cycle timer for "on-off" cycling of two independently adjusted load circuits.

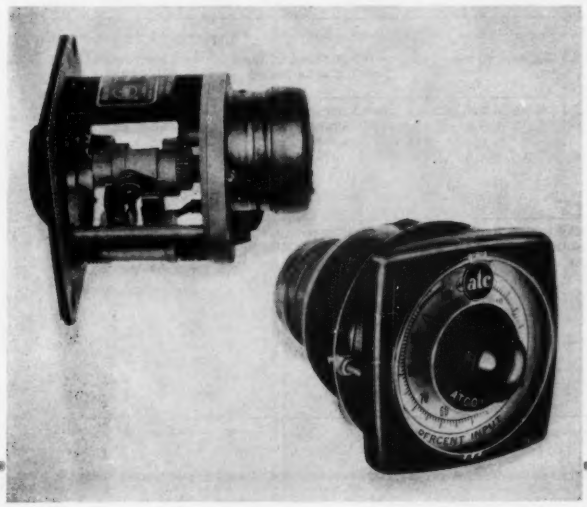


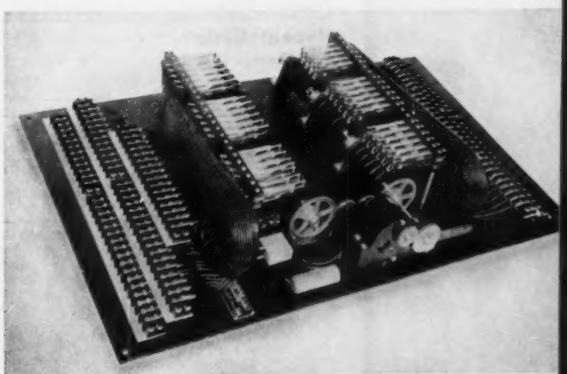
g—Pushbutton-type manual-start timer which repeats previously set time period. Second pointer indicates cycle progress.



j—Reset cam timer for repeat-cycle operation. Reset features and clutch are similar to those for the stop-cycle timer in Fig. 12*e*.

b—Percentage timer for accurate control of "on-off" operations.





k—Multicircuit cam timer for controlling the sequence and duration of one or a series of individually timed operations.

Table 1—Selection Guide for Basic Types of Timers

Basic Type	Number of Contacts or Circuits	Timing Range	Setting Accuracy	Repeat Accuracy
Stop Cycle				
Miniature: Synchronous-Motor Drive (Fig. 1)	4 independent, 2 dependent	0 to 15 sec up to 0 to 60 hr	±0.5 per cent of dial range	±0.25 per cent of dial range
Heavy Duty; Synchronous-Motor Drive (Fig. 3)	2 independent, 1 dependent	0 to 15 sec up to 0 to 120 hr	±0.5 per cent of dial range	±0.5 per cent of dial range
Screw-Adjustable; Synchronous-Motor Drive (Fig. 12*a*)	1 or 2	0.75 to 7.5 sec up to 1.5 to 15 min	Uncalibrated (see Manner of Setting)	±5 per cent
Electronic (Fig. 12*b*)	2, either independent or dependent	0 to 1 sec up to 2 to 120 sec	±2 per cent of setting	±2 per cent of dial range
Transistor (Fig. 12*c*)	4	0.03 to 1.5 sec up to 1 to 150 sec	±5 per cent of setting	±1 per cent of dial range
Cam (Fig. 12*d* and 12*e*)	1 to 100	1 sec up to several days	Uncalibrated (see Manner of Setting) 1 per cent on 2-in. diam cams; 0.5 per cent on 4-in. diam cams	±0.25 per cent of total cycle
Pneumatic (time-delay relay)	1 normally open, 1 normally closed	0.16 sec to 3 min	Uncalibrated	±10 per cent of setting
Thermal (time delay)	1	1 sec up to 200 sec	Uncalibrated	±10 per cent on short ranges to ±20 per cent on long ranges
Manual Start; Synchronous-Motor Drive (each time-period must be set) (Fig. 12*f*)	1, either SPST or DPDT	0 to 15 sec up to 0 to 24 hr	Approximately ±1 per cent of dial range	Depends on accuracy of each setting
Manual Start; Synchronous-Motor Drive (repeats preset time period) (Fig. 12*g*)	1 independent, 1 dependent	0 to 15 sec up to 0 to 60 hr	±0.5 per cent of dial range	±0.25 per cent of dial range
Fluid Dashpot (time-delay relay)	1	2 sec up to 30 sec	Uncalibrated	±15 per cent of setting
Repeat Cycle				
Percentage (Fig. 12*h*)	1	15, 30, and 60 sec	±0.5 per cent of max possible time period	±0.5 per cent of max possible time period
Dual Function (Fig. 12*i*)	2 independent	30 sec up to 240 min	±0.5 per cent of dial range	±0.33 per cent of dial range
Cam Fig. 12*j* and 12*k*)	1 to 100	0.6 sec up to several days	Uncalibrated (see Manner of Setting)	±0.25 per cent of total cycle

*Other than changing of dial setting.

Effect of Power Failure	Field Flexibility*	Manner of Setting	Comments
Can be adjusted either for reset or nonreset.	Adjustable to reset or nonreset if power fails. Unlimited circuit combinations possible. Motor and dial can be replaced for new timing range.	Dial set, direct reading.	Switches are DPDT precision type. Timers operating from dc require regulated supply for constant timing.
Is supplied as either reset or nonreset.	Unlimited circuit combinations possible.	Dial set, direct reading.	Available with vernier for dial-setting accuracy. Available with cycle-progress indication to show elapsed and remaining time in cycle.
Resets.		Adjustable screw; use per cent scale for rough setting, stop watch for accurate setting.	SPDT precision switches are operated at end of cycle. Low cost timing with instantaneous reset (reset time unaffected by "on" time). Timing unaffected by temperature.
Resets.		Dial set, direct reading.	One DPDT relay operates at start, other at end, of cycle. Timing accuracy unaffected by normal line voltage fluctuations. Dial assembly can be remotely located if space is limited.
Resets.	Adjustable for sustained start, momentary start, or rapid reset (for quick re-cycling).	Dial set, direct reading.	DPDT switches are operated at end of time delay. Dial assembly can be remotely located if space is limited.
Both reset and nonreset types available. Either can be made to restart automatically or wait for a start signal.	Over-all cycle can be changed by gear substitution. Per cent and point of closure for each contact can be changed by adjusting split cams.	Set adjustable cams. If so equipped, use cycle-progress dial for reference. Check by stop watch for desired accuracy.	Edge-reading cycle-progress disc or dial can be added. On multicircuit unit, entire camshaft assembly can be changed for rapid program changing. Available with either adjustable-speed drive or a two-speed drive with gear-shift mechanism for quick speed change. Can have multiple shafts rotating at different speeds with or without changeable gearing between them.
Resets.	Convertible from "on" delay (delay after coil is energized) to "off" delay (delay after coil is de-energized).		Auxiliary contacts available.
Begins to reset; resets fully if "off" long enough. Restarts delay period if starting contact is still closed.		Some types are set at factory; others have screw adjustment for use with stop watch.	Switch can be either normally open, normally closed, or SPDT. Line voltage and ambient temperature variations affect timing accuracy. Reset time is relatively slow; can vary with length of time unit is "timed out."
Does not reset.	Length of time cycle can be changed manually during timer operation.	Dial set, direct reading.	Knob must be set each time for length of time-period desired. Knob indicates cycle progress on dial. Can be used as "off-on" switch which operates load but does not start timer.
Does not reset.	Motor and dial can be replaced for new timing range.	Dial set, direct reading.	Both load switches are SPDT. Both transfer at start and again at end of cycle. Built-in pushbutton starts timer. Selected time period remains set for successive cycles. Pointer indicates cycle progress.
Resets.			Switch may be either normally open or normally closed. Minimum reset time is approximately 0.5 sec.
Does not reset.		Dial set, direct reading in per cent.	Switch is SPST.
Does not reset.	Length of either independent time period can be changed manually during timer operation. Manual override permits load switching at any time during cycle without interrupting timer motor.	Dial set, direct reading.	Two switches are each SPDT. Dwell period can be set between the trip point of the two switches.
Both reset and nonreset types available. Either can be made to restart automatically or wait for a start signal.	Over-all cycle can be changed by gear substitution. Per cent and point of closure for each contact can be changed by adjusting split cams.	Set adjustable cams. If so equipped, use cycle-progress dial for reference. Check by stop watch for desired accuracy of setting.	Edge-reading cycle-progress disc or dial can be added. On multicircuit unit, entire camshaft assembly can be changed for rapid program changing. Available with either adjustable-speed drive or a two-speed drive with gear-shift mechanism for quick speed change. Can have multiple shafts rotating at different speeds with or without changeable gearing between them.

accuracy usually does not take human error into account.

Dial parallax or readability error caused by incorrect alignment of the dial and setting reference also affect the setting of most timers. For most industrial uses, however, this error is not important because the timer setting will have to be "trimmed in" to suit other variables in the system. It is usually important only when it is necessary to repeat a known setting from previous tests. Even in this case, other variables in the system may necessitate minor adjustment.

Repeat: Repetitive accuracy is also stated as a percentage of the full-dial range of the timer. This statement of accuracy indicates that, for continuous cycling, each period will be within specified limits. This guarantee assures that a product will be uniform from one lot to the next.

Selection Factors

To derive the greatest benefit from any timing device, the unit best suited for the specific application must, of course, be chosen. Numerous factors are involved in the proper choice.

If the timing problem is a simple one, a timer may be selected from a catalog. But if the problem is complex, the designer should be ready to supply a complete and clear list of specifications and/or limitations to the timer manufacturer so the proper device can be recommended. The necessary specifications include:

1. Operating voltage and frequency.
2. Number of load circuits.
3. Action of loads (timing chart).
4. Current capacity of contacts.
5. Duty cycle.
6. Type of start and operation.
7. Timing range.
8. Setting and repeat accuracy.
9. Environment and enclosures.
10. Reliability.
11. Price range.

Each of these items will be discussed further. A general summary of various types of timers and related selection factors is given in Table 1 with accompanying illustrations in Fig. 12.

Voltage and Frequency: These factors are usually dictated by supply voltage at the job site. Standard operating voltage and frequency of most ac timers is 115, 230, or 440 volts, 25, 50, or 60 cps; other voltages and frequencies are also available.

Voltages available for dc operation are 6, 12, 24, 28, 32, 48, 125, and 250. Dc timer operation falls into three categories:

1. Nongoverned dc motor drive.
2. Governed dc motor drive.
3. Electronic and transistorized timers.

Speed of nongoverned dc timer motors is affected by voltage fluctuation, temperature change, and varying load. Governed dc timing motors have a built-in speed inaccuracy when the motor starts, but for the remainder of the timing cycle the timing accuracy is comparable to that of an ac timer.

Electronic and transistorized timers for short-interval time control are unaffected by voltage fluctuation, temperature change, and varying load. A typical transistorized timer is a time-delay relay for intervals from 50 milliseconds to 4.0 min. It maintains an accuracy of ± 4 per cent over a supply voltage variation of ± 10 per cent. Repeat accuracy is better than 1 per cent for any time cycle. These timers operate successfully in temperatures ranging from -40 F to $+125$ F.

Load Circuits: The number of steps in a process will determine the number of load circuits required by a particular timing network. In the two-station paint-spraying example described elsewhere in this article, seven load circuits are required for the necessary steps.

Load Action: Load action refers to the electrical function of the timer. A load circuit is directed to either a single or a multicircuit contact. For a single time-function stop-cycle timer, for example, three modes of timer load action must be considered: 1. Before start. 2. During cycle. 3. End of cycle.

Contact Capacity: Current-carrying capacity of the contacts is related to line voltage and frequency of the load. When timers are selected for a specific service, the contacts must not be required to operate a load beyond their capacity. The average timer has a contact rating of 10 amp at 115-v ac noninductive, 5 amp at 230-v ac noninductive, and 1 amp at 440-v ac noninductive.

When timers are designed into a circuit, it should be determined whether the timer will merely handle pilot loads, such as relay coils, or whether it will handle the external load directly. In some applications, heavy-duty industrial-type timers can handle loads directly. Standard timers are available with contact rating up to 25 amp at 115-v ac. Use of such timers can often eliminate an auxiliary contactor with resulting reduction in initial purchase cost, savings in space, and simplification of electrical design.

Because most loads (relays, solenoids, small motors, etc.) are inductive, they should be checked carefully for inrush as well as maintaining current. As a general rule, a contact used for an inductive load will have approximately one-fifth of its noninductive rating. For filament or lamp loads, contact rating should be further reduced to at least 1/10 of the noninductive rating.

Life-load characteristics of contacts cannot be predicted with accuracy from a test at just any given duty cycle and load. The only practical means of evaluating contact life is to operate the switch at maximum anticipated duty cycle with maximum

Fig. 13—General purpose NEMA Type 1a enclosure for one or two interval timers.

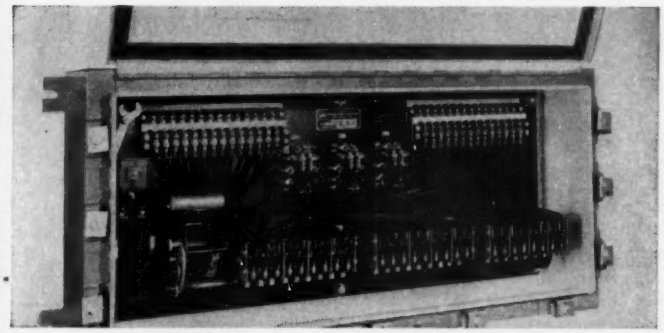


Fig. 14—Watertight NEMA Type 4 enclosure for multicircuit cam timer. Often, a change of gasket material can make a basic enclosure suitable for other classes of service.

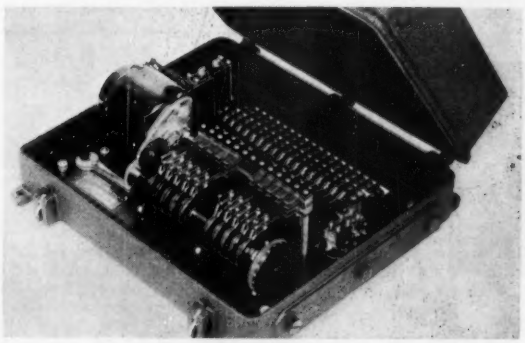
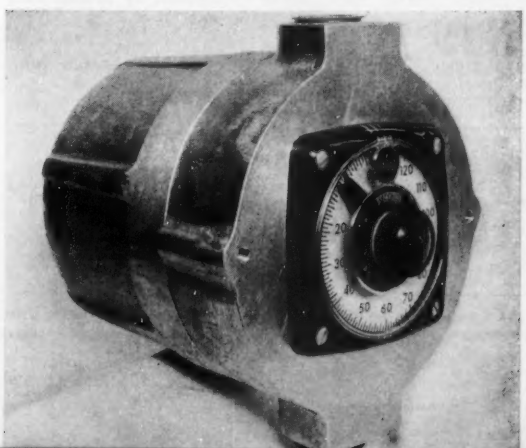


Fig. 15—Dusttight NEMA Type 5 enclosure containing multicircuit cam timer with calibrated setting disc.

Fig. 16—Hazardous location, NEMA Type 7 enclosure containing a miniature dial-set timer.



intended load. If a contact is tested with a load greater than anticipated or at a higher operating rate, false life-expectancy results will be obtained. A contact operated at an above-normal cyclic rate does not have time to cool properly and, therefore, is not capable of carrying the rated current. A reduced-current rating will be required until the switch members can dissipate the heat as quickly as it is generated. Before this point is reached, however, the contacts may reach temperatures 50 to 60 deg C above ambient. To compensate for this problem, either the load should be reduced or a switch with higher contact rating should be used for long life.

Duty Cycle: Selection of many heavy, medium, and light-duty industrial timers depends on their frequency of operation. This frequency of operation also determines whether the timer should be a mechanical or electronic type. For example, where the machine or process being controlled requires a timer to perform rapid cycles at some point during the operation, a heavy-duty industrial type might meet the requirements, but an electronic or transistorized timer could well be considered.

Start and Operation: If the timer should have its own maintaining circuit so that its pattern may be completed even though the starting contact is reopened, a momentary start is indicated. If the contact must remain closed, then a sustained-start method of operating applies.

Timing Range: The minimum-maximum time setting is known as the time range. When time and range are considered, it must be realized that the average dial-set timer has a minimum setting of approximately 1 per cent of the timer's total cycle. For example, in a dial-set repeat-cycle timer application with a repeating on-off operation—off four hours, on four seconds—the four-second setting could not be obtained with a four-hour timer. Consequently, it would be necessary to use two stop-cycle timers, one having a range of 0 to 15 sec, the other a range of 0 to 4 hr. The two timers would be wired for alternating repeat-cycle operation.

Manner of timer setting also falls in this selection category. It must be determined whether the increment of setting should be infinitely adjustable, adjustable in steps, or fixed.

Accuracy: Requirements of accuracy should be specified to suit the application. Thus, if a timer is required for a delay period, purchasing a unit with high setting and repeating accuracy would be unnecessary when a unit with a 5 to 10 per cent tolerance would be adequate.

Environment and Enclosures: A wide variety of enclosures corresponding to almost any operational environment is readily available. However, in the selection of specific types, several descriptive terms are often used: Dusttight, general purpose, water-

Typical Design Problem

tight, weatherproof, submersible, moisture-resistant, acid-resistant, fume-resistant. Standard definitions for these terms have been adopted by NEMA.* Some representative NEMA enclosures are shown in Fig. 13 through 16.

Reliability: In applications where costly downtime

*Industrial Control, NEMA Standards Publication No. IC 1-1959. Section 1, Part 2, p. 7.

Often, two or more timing arrangements will perform equally well for the same application. In such instances, the designer must consider the unusual requirements of the application in order to narrow his selection to the best one.

Specifying timing controls for a theoretical two-station paint-spraying production line presents just such a problem. Seven timed steps are required in this example, each step requiring a circuit. The timing sequence is:

1. Energize the conveyor indexing motor to move the piece to be painted to station one.
2. Energize a clamp to position the piece for painting.
3. Energize a solenoid valve to spray paint for a definite time period.
4. Energize the conveyor indexing motor to move the piece from station one to station two.
5. Energize a pusher mechanism to rotate the piece.
6. Energize a solenoid valve to spray a second coat of paint for a definite time period.
7. Energize an ejector to push the finished piece off the conveyor.

This sequence of operations could be obtained by any of three methods: 1. Multicircuit cam timer. 2. A series of seven interval timers. 3. One sequence contactor and one multidial electronic timer.

Initial Considerations

1. **Multicircuit timers:** A seven-circuit cam timer, Fig. A, could be custom-engineered for the paint-spraying production line. General characteristics are covered more thoroughly under *Multicircuit Timers*.

2. **Interval Timers:** A series of seven automatic reset timers, or single time-function interval timers, Fig. B, could be set up to provide the sequenced operations. The interval timer is a dial-set automatic-reset timer with dial ranges from 0 to 15 sec up to 0 to 240 hr. Load-contact action is usually single-pole double-throw. In some instances, however, more contacts are available—some timers have double-pole double-throw clutch contacts, some have double-pole double-throw motor-actuated contacts. Load contacts can be used in circuitry requiring either delayed opening or delayed closing or a combination of both. Ordinarily, the basic timer uses only a single timed function.

Interval timers have many advantages. Their time-load contact action can be field-adjusted. Over-all time cycle is readily adjustable over the entire dial range and, since each time function is independently adjustable, there is no need to stop the process to change cycle time.

Also, a timing scheme can be designed using standard off-the-shelf timers. Thus, specifications need not be prepared to have the timer custom-built.

3. **Sequence Contactor, Electronic Timer:** A third possible timing program could use an electronic timer chassis, either vacuum tube or transistor type, seven remote dials, and a stepping contactor, Fig. C. This system, especially with a transistorized timer, would provide excellent reliability and long life.

One design consideration of importance would be the relatively restricted dial range of an electronic timer. Operation of this control scheme would be similar to that for the system using reset timers. The separate dial assemblies permit individual and instantaneous selection of each time interval with no need for stopping the process to change cycle time.

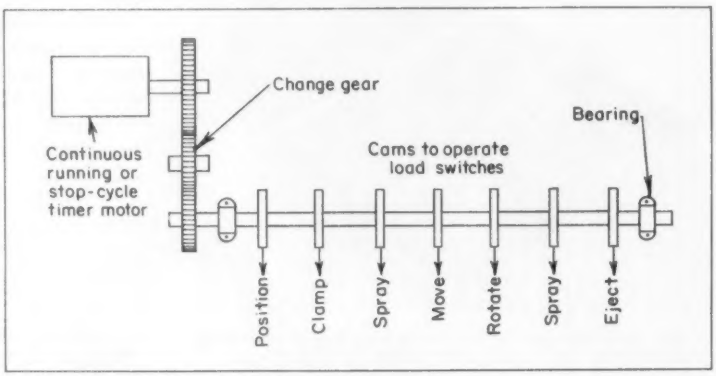
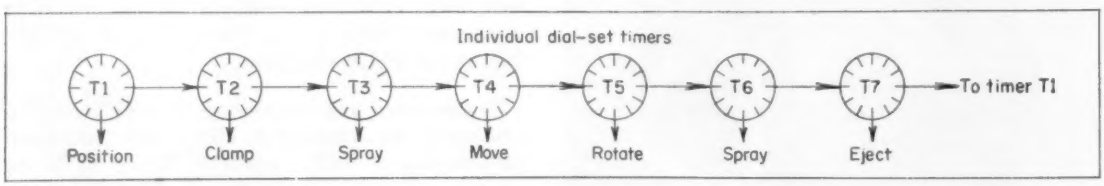


Fig. A—Multicircuit cam timer. Seven cam-operated switches provide sequential control of paint-spraying functions. Total cycle time (360 degrees of cam rotation) is adjusted with change gears. Each circuit is adjusted by setting each split cam.

Fig. B—Series of interval timers. Each dial-set timer controls a separate function and also energizes the next timer for complete sequential control.



should be considered, the designer has a choice of plug-in timers or timers made for high reliability, such as the heavy-duty industrial type. Timers designed with plug-in connections find use on high-speed, high-production machines or processes. The primary virtue of such timers is ease of replacement.

Price Range: Often, two or more timing arrangements may be designed for the same applications. Consequently, prices may vary widely for the different systems. In such cases the final selection has to be made by comparing the features provided by each system rather than by comparing cost alone.

Diagrams

In many cases, especially if a timer is used as part of a complete control system, diagrams help

Final Selection

System Flexibility: The need for system adjustment must be determined. For example, if the production line is to turn out the same item day after day, a multicircuit cam timer would be the best choice. However, if different items are to be painted, spacing on the conveyor and the amount of paint applied at each station would both vary. In this case, either a combination of sequence contactor and interval timers or a series of interval timers would be more suitable.

For a temporary paint-spray production line, an interval-timer scheme would be best. Consider a job-shop which accepts a contract to paint several thousand tool boxes. After the order is completed, the production line is torn down. If a multicircuit cam timer were custom built for this application, it would be of no further use. However, interval timers could be used to work out timing networks for future applications.

Other Considerations: Final choice of a timing scheme may also be influenced by the factors which follow. Under each factor, the three systems are listed according to suitability, the best approach being listed first.

INITIAL FIELD SETUP

1. Interval timers. Timing equipment is readily installed for early operation. Each timing function is dial adjustable, thus providing maximum flexibility. Timer dial settings may be adjusted while equipment is in operation.

2. Sequence contactor and multidial electronic timer.

3. Multicircuit cam timer.

MAINTENANCE AND REPLACEMENT

1. Multicircuit cam timer. Construction is simple and there are few parts to wear out.

2. Sequence contactor and multidial electronic timer. This scheme has fewer components than a series of interval timers.

3. Interval timers.

MINIMUM AMOUNT OF DOWNTIME

It is desirable to maintain production with minimum downtime for adjustments. However, operation of conveyor and paint-spray equipment may become sluggish because of wear. It may occasionally be necessary to readjust the timing cycles.

1. Sequence contactor and multidial electronic timer. Fewer components are involved than in a series of interval timers. More critical timing periods are controlled by dial-adjusted timers.

2. Interval timers. Adjustments are easier than with a multicircuit cam timer.

3. Multicircuit cam timer. Timer cam settings and over-all time cycles cannot be changed while the equipment is in operation—the production line must be shut down. Cams are reset by trial-and-error methods.

PURCHASE COST

The systems are ranked from least to most expensive on the basis of having the timer manufacturer mount and wire the equipment in a complete package.

1. Multicircuit cam timer.

2. Sequence contactor and multidial electronic timer.

3. Interval timers.

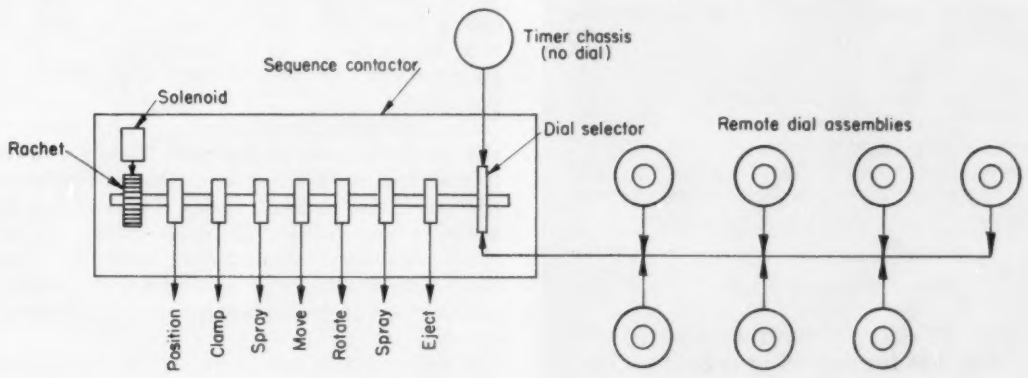
AVAILABILITY

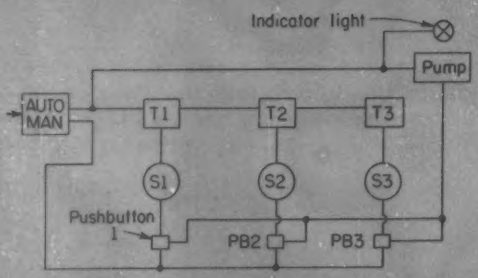
1. Interval timers. Because timer manufacturers usually stock single function, interval dial-set timers, they are easily obtained in a short period of time.

2. Multicircuit cam timer. These timers are custom-built to specifications. However, all necessary parts for assembling a unit are stocked so that any delay is the result of normal processing of the job through engineering and assembly departments.

3. Sequence contactor and multidial electronic timer.

Fig. C—Sequence contactor and multidial electronic timer. Each contactor controls a function and also selects a dial for connection to the timer chassis. Each dial setting determines the timing interval for the timer. After time-out, the sequence contactor "steps" another position and the cycle continues.





a—Schematic of electric circuit.

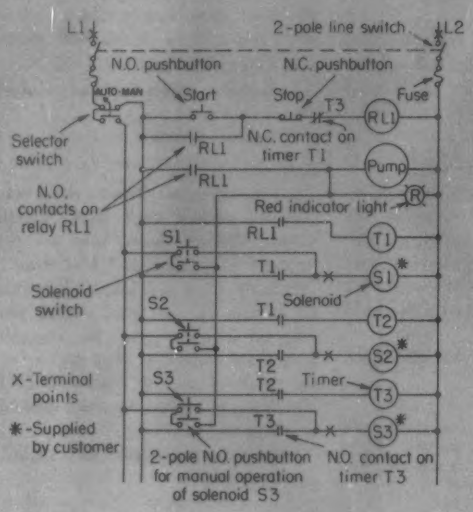
Automatic operation

1. Push start button: Pump starts, indicator light comes on, timer T1 starts, solenoid S1 is energized.
2. Timer T1 times out: Solenoid S1 is de-energized, timer T2 starts, solenoid S2 is energized.
3. Timer T2 times out: Solenoid S2 is de-energized, timer T3 starts, solenoid S3 is energized.
4. Timer T3 times out: Solenoid S3 is de-energized, pump stops, indicator light goes out, all timers reset.
5. Push start button to start new cycle.

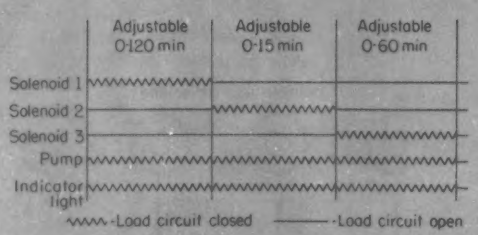
Manual operation

1. Any solenoid may be energized by pressing the corresponding pushbutton.
2. Pump runs and indicator light is lit when any solenoid is energized.

b—Sequence of operation.



c—Conventional control-circuit schematic which should be accompanied by a written description.



d—Timing chart.

Fig. 17—Simple timer application and diagrams for providing necessary information on operating sequence.

keep the timing operations clear in the designer's mind and also aid in the selection of the actual timer for the job. A block diagram wiring sketch, timing-sequence chart, and/or written description of the operational sequence are desirable. Diagrams submitted with JIC (Joint Industrial Committee) numbering often do not require accompanying written description, depending on complexity of the process.

When diagrams are prepared, generally accepted and easily understood symbols and terms should be used. The simple system with diagrams, Fig. 17, illustrates the types of information which may be furnished. Other methods for indicating timing sequence are shown in Fig. 18. Of course, it is not necessary for the designer to supply all the sketches represented in Fig. 17 and 18. They are included only to show the various ways in which a timing requirement can be indicated.

Multicircuit Timers

Multicircuit timers control the sequence and duration of any number of individual functions by controlling the load circuit to each function for the necessary length of time. In general, the type of multicircuit timer required will be indicated by the length of the time cycle and the number of load circuits to be controlled.

Where simplicity, flexibility, and reliability are desired in controlling 1 to 100 load circuits, a multicircuit cam timer, Fig. 19, may be used. A synchronous motor drives a shaft to position cams which actuate electrical switches or air valves in a fixed sequence.

Occasional program changes are made by easy substitution of camshafts. Over-all time cycle, or the time required for a cam to make one revolution, is adjusted by changing the camshaft gear in the sector-mounted gear train between motor and camshafts. This means the cycle is adjustable in fixed steps; it is not infinitely adjustable. However, changing the over-all time cycle does not affect the time relationship between contacts. Thus, a change proportional to the over-all cycle change is introduced in all contact closure periods within the cycle.

Change gears are available with each gear sector to allow cycle speed to be varied in small increments over a large range. For example, a fast cycle of 3 min can be varied up to approximately a 20-min cycle through appropriate sector gearing and change gears.

Contacts are infinitely adjustable with relation to any particular point in the cycle. Duration of contact closure, however, is adjustable over a limited portion of the over-all cycle. Types of contacts available are: Single-pole single-throw, normally open; single-pole single-throw, normally closed; single-pole double-throw; double-pole single-throw, normally open; double-pole single-throw, normally closed.

Many variations and accessories, such as external shafts, indicating dials, and setter discs, can be supplied with multicircuit cam timers. Usually, such

timers are designed to perform one sequence of timing and, hence, are not readily adaptable to other timing sequences. However, the multicircuit cam timer is usually constructed of standard stocked parts to permit custom assembly without premium cost.

Sweep-Arm Timers: Controls from 120 to 6300 circuits. A synchronous motor driven rotating balanced arm with finger type contacts traverses a pin-board providing pulses one at a time with no overlap. The pins are wired to a patchboard similar to a telephone switchboard. The motor drives the arm at a synchronous speed continuously unless interrupted by an external command signal. Individual circuit contacts in the total program can be changed or interchanged by relocating a jumper cord position on the patchboard.

Controlled load circuits are thus governed by pulsed signals from the sweep arm timer. Duration of pulses depends on the total time cycle. The pulse from the sweep arm timer usually operates relays which are energized and lock up either by a mechanical latching device or an electrical holding-in contact.

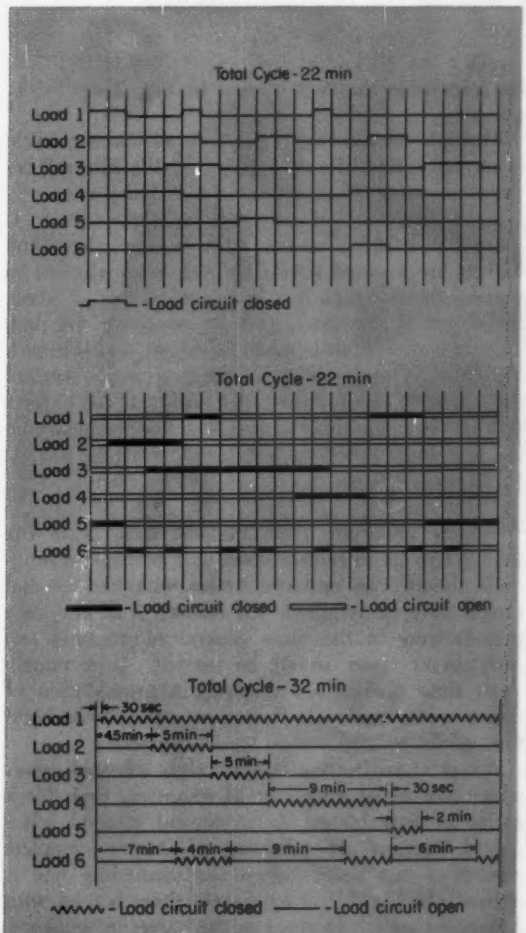


Fig. 18—Three different methods for indicating timing sequence for three different systems.

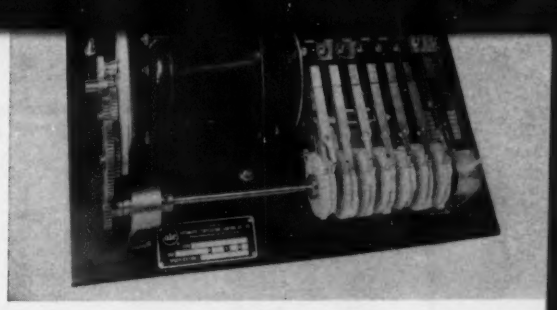


Fig. 19—Typical multicircuit, multicam timer with adjustable split cams.

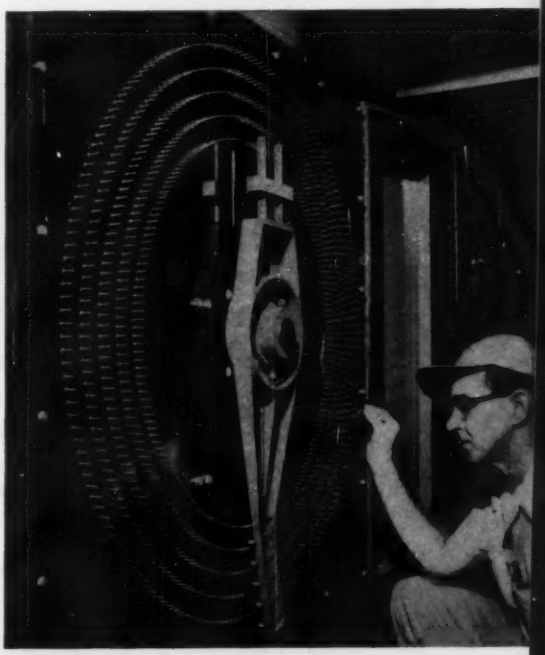


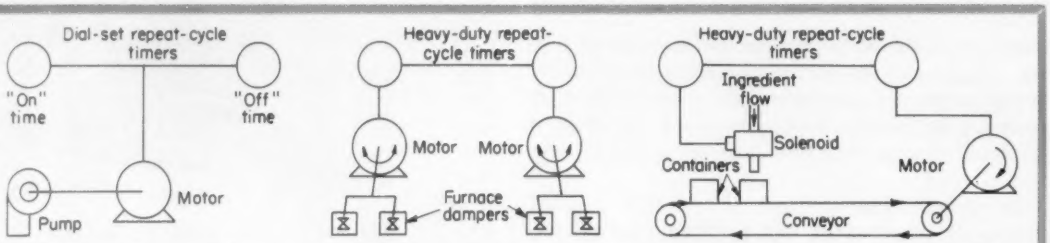
Fig. 20—Sweep-arm timer used for special applications where up to 6300 circuits must be controlled.

Timer Combinations

Where multicircuit timers cannot meet the demands of a particular application, a combination of timers can be designed into the timing network. Typical applications where timer combinations may be used are illustrated for the following conditions:

Independently Adjustable Load Circuits: The requirement for multiple independent load adjustment cannot always be met by a multicircuit cam timer where this feature is somewhat limited. It can be met by using two or more dial-adjustable timers. Specific timer choice depends on the selection factors previously outlined.

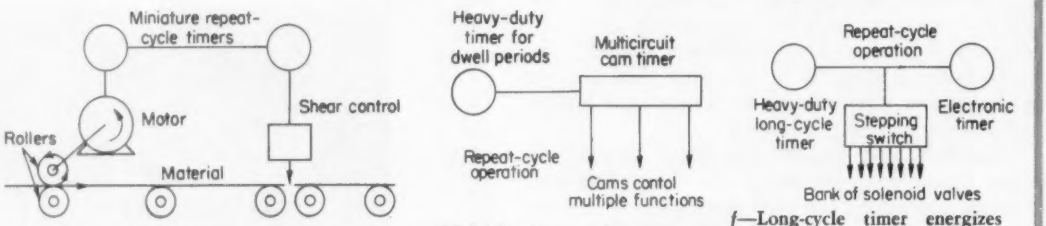
For example, in a sequential operation where pump "on" time varies with demand, it would be undesirable to make time-setting changes with cam wrenches and change gears. Dial timers, however, afford quick and easy adjustment, Fig. 21*a*. Single unit timers with two setting hands, Fig. 12*i*, offer



a—Dial-set timers permit independent adjustment of motor "on" or "off" time.

b—Repeat-cycle reset timers alternately energize damper motors for independently adjusted time periods.

c—Nonreset timers control time for filling container and for moving conveyor predetermined distance to place empty container in filling position.



d—Inexpensive miniature timers for controlling material feed and cut-off may be either reset or nonreset type.

e—Multicircuit cam timer controls fixed time periods for conveyor movement while dial-set timer permits convenient adjustment of dwell periods.

f—Long-cycle timer energizes stepping switch to operate valves for constant but sequenced time periods, and electronic timer provides two-second delay to ensure valve closure.

Fig. 21—Block diagrams of possible applications of timer combinations

individual timing adjustment for two separate control circuits.

Repeat Cycle Operation: Two dial timers may be interwired to give repeat-cycle operation. Thus, two loads may be energized alternately, or one load may be energized with an interval between successive energizations. Standard timer combinations to perform these functions are:

1. *Two reset timers*: Fig. 21*b* illustrates an application for furnace damper operation where two devices are energized alternately for independently adjustable time periods. In another application, one timer energizes a conveyor motor to move a belt a predetermined distance; the second timer controls the dwell period, or the length of time the belt is stopped.

In both applications, the timers must reset in the event of power failure so that the cycle can be started from the beginning when power returns.

2. *Two nonreset timers*: This timer combination is sometimes used to control a filling operation, Fig. 21c. One timer governs the length of time an ingredient flows into a container, and the second timer determines the interval during which the filled container is removed and an empty container takes its place. If power failure occurs while a container is being filled, it is important that the timer does not reset. Otherwise, when power returns, the filling time would start from the beginning and cause overflow. Therefore, the filling operation must resume from the point of power interruption.

3. *Two timers for either reset or not reset*: A material feed and shearing set-up that can use smaller, less expensive timers is shown in Fig. 21*d*.

Multiple Sequencing Cycle: A sequencing cycle is set on a multicircuit cam timer; the interval between sequencing cycles is set on a dial timer.

In a conveyor process, for example, work is placed in baskets, moved to a station where the baskets are lowered into a treating tank, allowed to remain in the tank for a preset period of time, raised out of the tank, and moved along the line. The adjustable dwell period is set on a dial timer, Fig. 21*e*. The fixed cycle—forward movement of the conveyor and lowering and raising of the baskets—is set on a cam timer although not actually to time the individual functions but to initiate timed periods in proper sequence.

Widely Different Time Periods: Because of the inability to set extremely short time periods on long-cycle timers, two or more timers with various dial ranges may be required. Of course, if all the time periods were in the same general range, only one multicircuit timer would be needed. If extremely short time periods are required, a combination of two or more electronic timers, or a mixed combination, might be used.

A typical application involves eight solenoid valves which are to be energized in sequence, each for a period of four hours. A two-second interval is required between energizations to assure complete closure of one valve before the succeeding one is opened. In Fig. 21*f*, a long-cycle timer is used with a stepping switch to energize the valves in sequence. A short-cycle timer provides the two-second interval.

organizing

CATALOG FILES

for efficiency

GLORIA EVANS
Engineering Librarian
Parke, Davis & Co.
Detroit

UP-TO-DATE company brochures and catalogs are valuable sources of information on the latest developments, products, applications, and techniques of modern industry. Unfortunately, the very mass of trade literature is the main hindrance to its use. How can so much material be utilized effectively? How can the right catalog be found when needed? Too often, the only way is to rely on memory or be forced to sort through floods of material.

This need not be the case. Careful selection and

logical indexing can transform a haphazard collection of literature into a valuable tool for design and specification.

Which System?

Each catalog filing system must be tailored to fit a set of requirements. One engineer may need a classification by manufacturer. Another may prefer the subject approach, a system wherein brochures, clippings, magazine reprints, and parts lists can be kept in the same file. A third may require a combination of the two.

All systems have two major objectives: 1. Fast, orderly organization of material. 2. Immediate availability of information. Final choice of method depends on the intended use of the material. Simplicity should be the keynote so that additions and deletions can be made readily. Regardless of the indexing system, certain rules are basic:

1. The collection should not be overburdened with superfluous material.
2. Every piece of literature is dated as it is filed. Without a date, efficient weeding or discarding is impossible.
3. A concise list of subject headings should be developed, covering the anticipated needs.

Four basic systems, Table 1, are generally used to file and index trade literature.

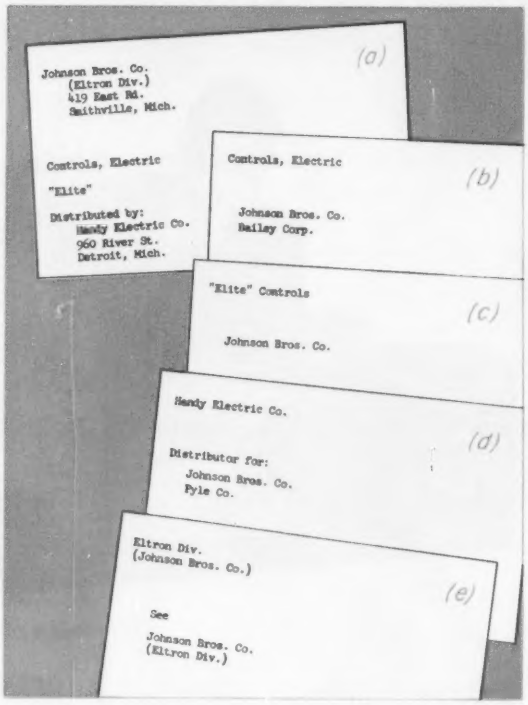


Fig. 1—Master index card, *a*, and supporting cards for complete indexing. Card *b* is subject or product entry; *c*, trade-name entry; *d*, distributor or vendor entry; *e*, parent or subsidiary company entry. A separate product card is made for each of the manufacturer's products.

Table 1—Four Basic Catalog Systems

1 File by Product—No Index

- Material is dated, labeled, and placed in product folder.
- Manufacturer's name is added on outside of folder.

2 File by Manufacturer—Index by Product

- Material is dated and filed in manufacturer's folder.
- Manufacturer's name is entered on product index card.

3 File by Product—Index by Manufacturer

- Material is dated, labeled, and placed in product folder.
- Product is entered on manufacturer's index card.

4 File by Product—Index by Product

- Material is dated, labeled, and placed in product folder.
- Manufacturer's name and most recent date of literature is entered on product index card.

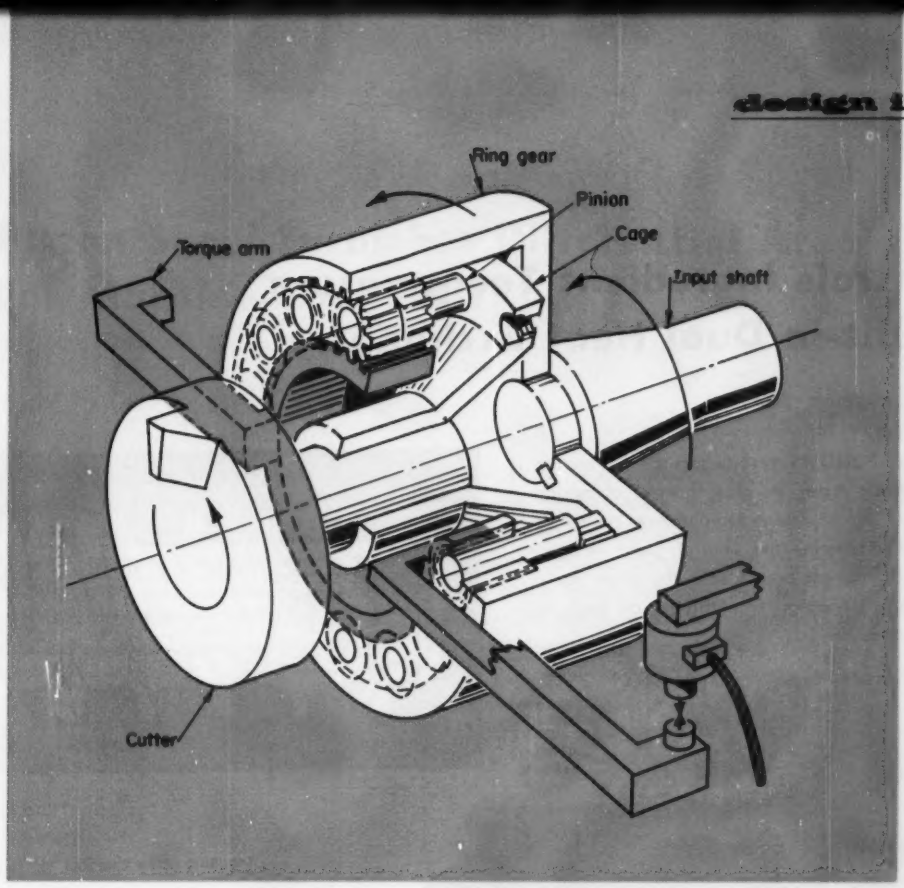
When a catalog file is used by several persons, or must provide information from any of a number of starting points, a more complete indexing system is necessary, Fig. 1. This involves the addition of cards for tradenames and venders, and can include a cross-index on parent and subsidiary-company names.

Some types of material can present an indexing or a storage problem, or both. For example, the large distributor's catalog often contains several manufacturers' products and/or more than one type of equipment. Methods of handling this type of literature are: 1. The catalog is taken apart and each piece of literature handled individually. 2. The catalog is maintained as a unit, with index cards properly noted to provide information on the catalog's contents.

Keeping Up to Date

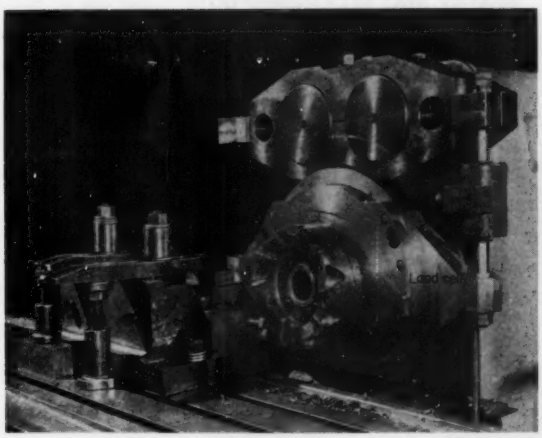
The key to a good catalog file is simple: The file must be up to date, and it must be kept free of obsolete and superfluous material. New data sheets, price lists, and tearsheets are added to the files as they arrive.

If the index cards are dated, they should be checked once or twice a year. Manufacturers who haven't been heard from for a year or more can be contacted for new material or price lists. A preprinted postcard is a practical method to handle the request. The literature itself should be checked annually for obsolete material and misfiled items.



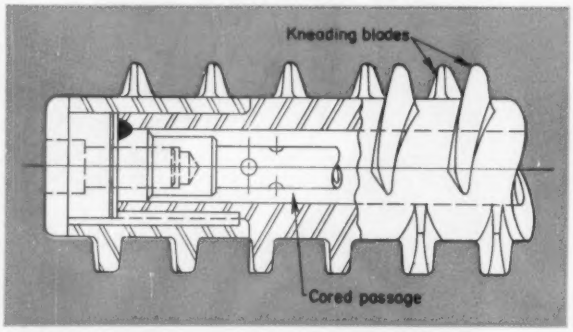
Planetary Gearing in Torquemeter Does Away With Sliding Contacts

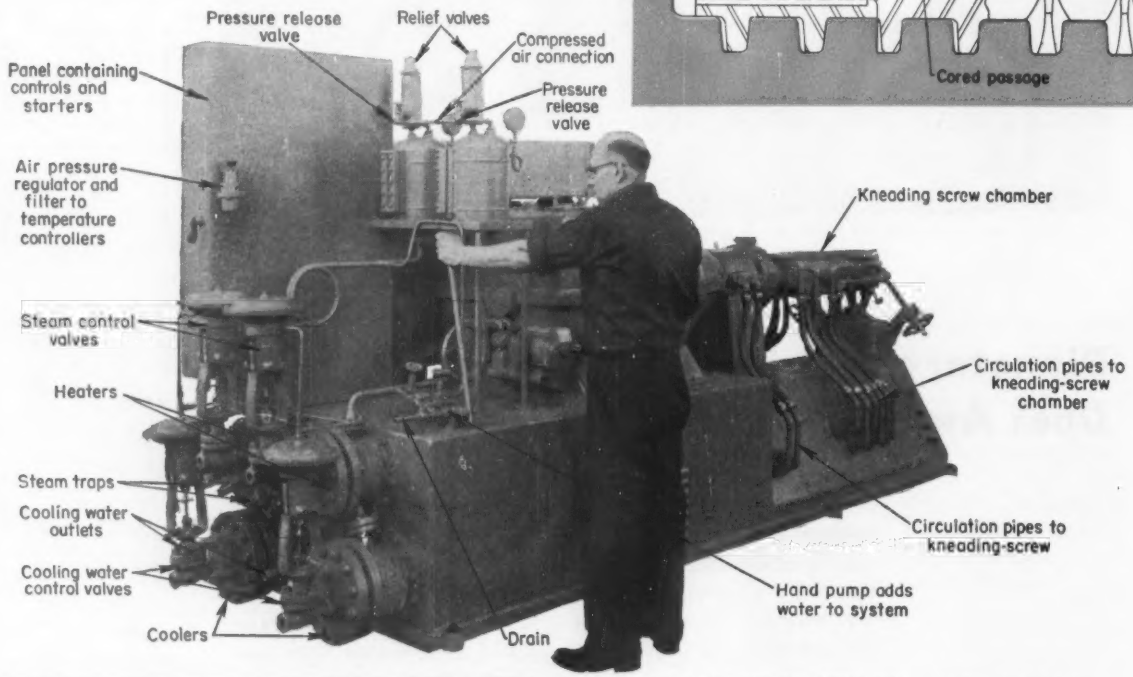
TORQUE IS PICKED OFF of a rotating spindle without slip rings by using a planetary gear train and attaching a strain gage to the stationary sun gear. Drive through the planetary gear train is from ring gear through pinions to pinion carrier. This satisfied a requirement that output speed be somewhat lower than input. Since the sun gear doesn't move, almost no power is lost and the transmission has an efficiency of 99 per cent. The rugged unit is usable over a wide range of speeds. Any of a number of mechanical, electric, or hydraulic strain gages or load cells may be used with the torquemeter as suits the user's needs. Torquemeter was developed by J. R. Roubik in the Metal Cutting Research Dept. of Kearney and Trecker Corp., Milwaukee, and was described in a recent ASME paper.

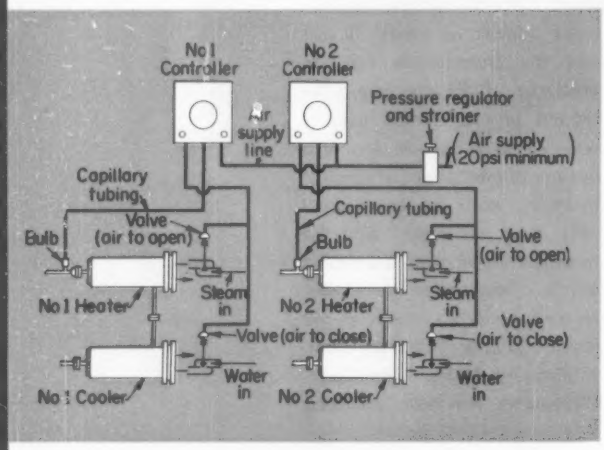


Mixer Controls Ingredient Temperature With Built-in Dual Heat Exchangers

CIRCULATING FLUID FOLLOWS cored passage in mixing screw of a new plastic mixer for close control of mixing temperatures. Other areas where temperature control is important are the discharge die, barrel, and hopper. Versatility of the heating equipment suits the mixer for a large variety of jobs. Mixing temperatures as high as 600 F can be maintained.





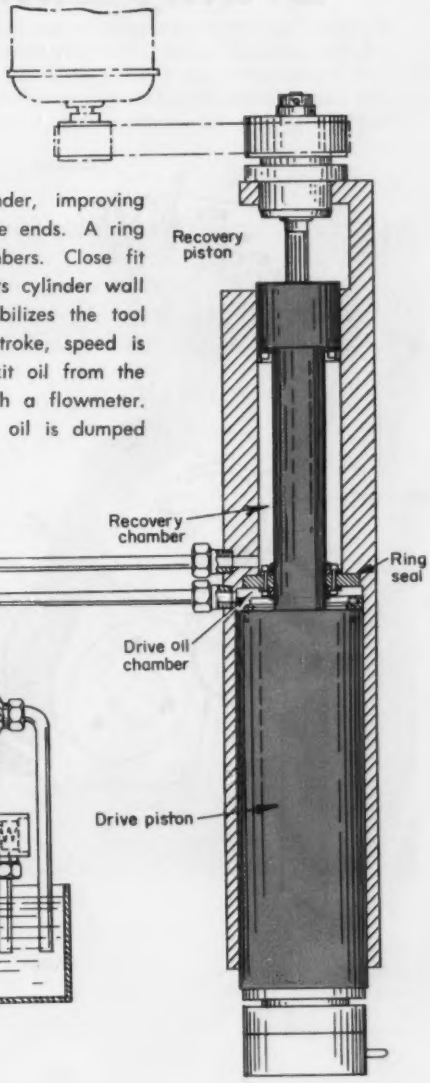


BUILT-IN HEAT EXCHANGERS DO a better job of temperature control than heating and cooling accessories usually used. Heating and cooling units are coupled to work together. As pneumatic signal closes one, it opens the other for continuous positive control. Additional versatility is built into the system by making heat-exchanger tube bundles interchangeable with 24 kw electric immersion heaters to maintain temperatures above 370 F. Water is usually the circulating medium with steam used in the primary heating coils, and raw water used in the primary cooling coils. With the immersion heaters oil is used as the circulating medium.

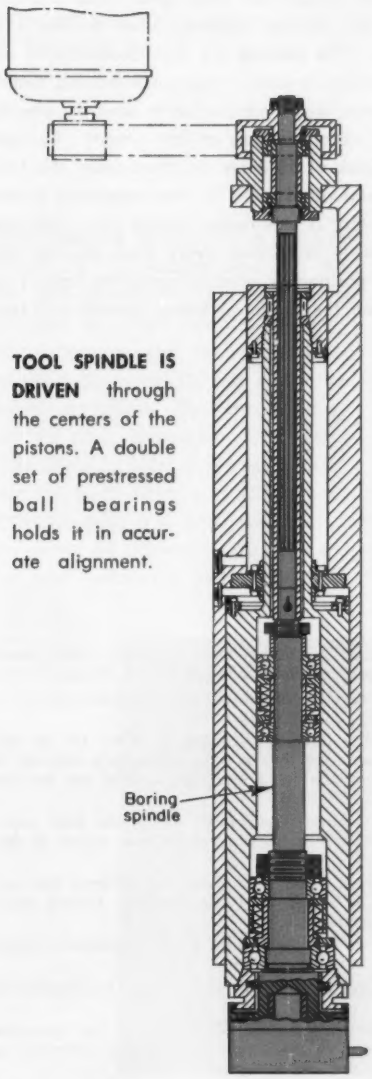
Plastic mixer with built-in temperature controls was developed by Baker Perkins Inc., Saginaw, Mich. Heat exchangers for the system were developed by American-Standard Industrial Div., Detroit.

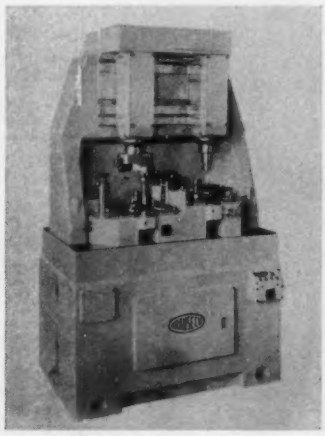
Piston Spool Furnishes Differential Area For Machine-Tool Feed

ACTIVE CROSS SECTION IS VARIED between feed and recovery strokes in the hydraulic feed cylinders of a boring machine by using a two-piston spool. Internal position of both drive and recovery chambers simplifies end sealing problems and makes possible hose connections at the center of the cylinder, improving appearance of the visible ends. A ring seal separates the chambers. Close fit of the drive piston to its cylinder wall for its entire length stabilizes the tool spindle. On the feed stroke, speed is controlled by passing exit oil from the recovery chamber through a flowmeter. On the recovery stroke, oil is dumped directly into the reservoir.



TOOL SPINDLE IS DRIVEN through the centers of the pistons. A double set of prestressed ball bearings holds it in accurate alignment.

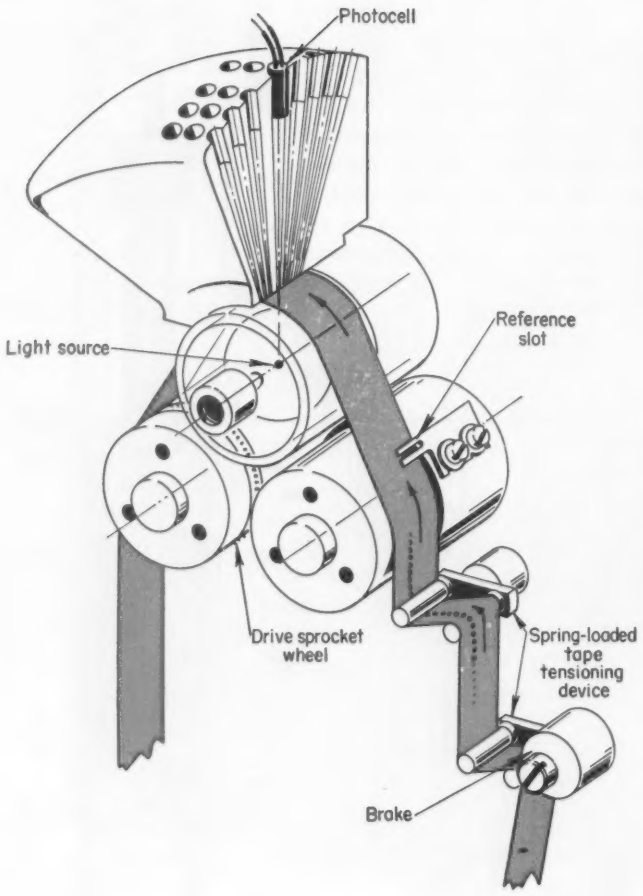




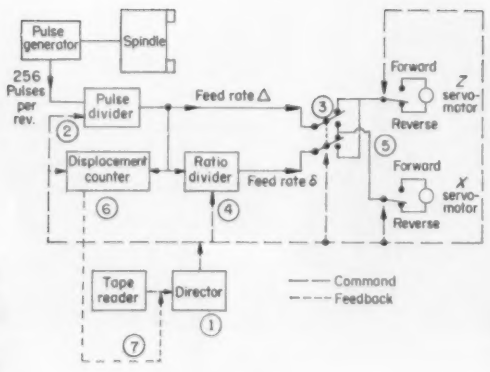
Multiple-spindle boring maching using the hydraulic feed is a development of Siemens & Halske AG, Munich, Germany.

Brainy Lathe Uses

Light Path Information Routes



RADIATING HOLES TRANSMIT light signals from tape to photoelectric cells in a block tape reader developed for the lathe. Diverging pattern serves two purposes: 1. It provides a number of straight-line paths from a single light source. 2. It provides room to mount quarter-inch photoelectric cells that must read perforations spaced 0.1 in. center to center. Tape-tension regulator includes a braking device that locks when tape tension is eased, but releases instantly when tension is increased. This permits the high accelerations and decelerations needed in the block reading system. Tape drops into a tumble bin to save the possible drag of storage spools on the system. By reading a block of 18 lines simultaneously, the block reader eliminates need for the temporary storage register that a line reader would use. Reference slot, exactly one block away from the first hole reading position, is used to locate the holes properly when the reader is being loaded with tape.



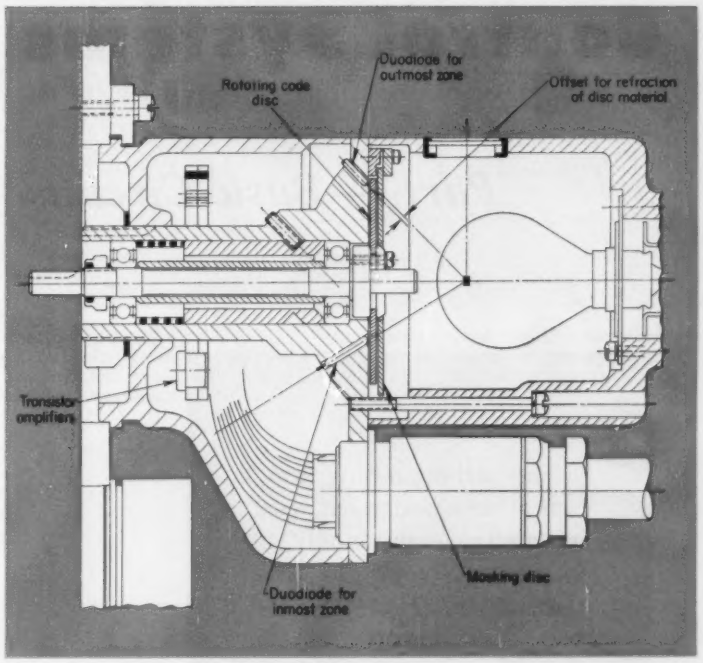
TAPE CONTROLS CONTOUR by producing many short, straight cuts within the tolerance envelope. Here's how a sequence works:

1. Block tape reader inserts a command with complete details into the director.
2. From the details the director furnishes a factor to the pulse divider which uses the factor on the pulse generator's constant 256 pulses per revolution to produce a feed rate, Δ, that can be translated into inches per revolution.
3. Director operates electronic gating to apply the feed rate Δ to the proper servomotor. Servomotors drive lead screws to move the turret.
4. Ratio divider produces a secondary feed rate, δ, from the major rate and another factor supplied by the director. Gating applies this rate to the other servomotor.
5. Director sets forward or reverse for each servomotor through additional gating.
6. Director also sets required length of cut on the displacement counter.
7. Displacement counter "counts down" to zero as feed progresses, and triggers the director to drop out the completed command and accept a new one from the tape reader.

To Speed Reaction Time

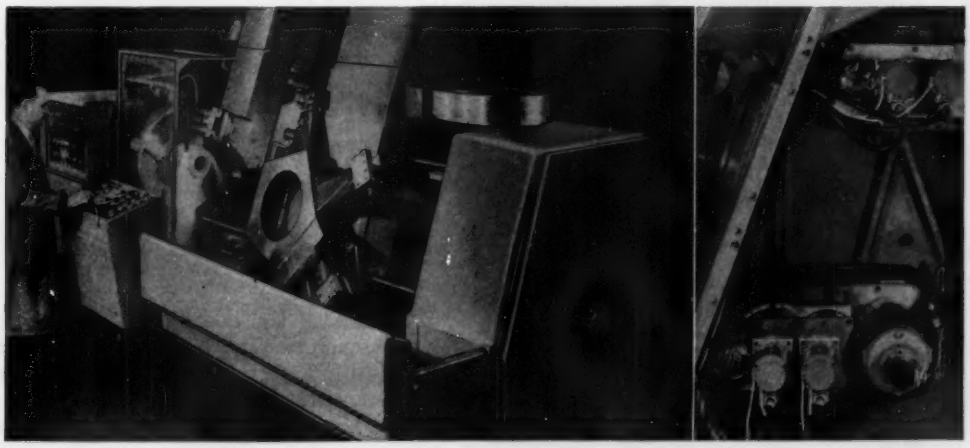
Pencils of light are quick-acting nerves in a closely controlled automatic turret lathe. Located at potential slow-up spots they keep information and commands flowing smoothly at speeds that can reach 10,000 bits per second.

NUMERICAL CODE PRINTED on a code disc consists of opaque and transparent patches grouped in concentric tracks or "zones." These are illuminated by a light source and "read" by silicon duodiodes through slots in a masking disc. Duodiodes change electrical resistance under the influence of light. The disc rotates with the turret lead screw and produces a running account of the turret position to be read off by the duodiodes.



LOCATION OF TURRET along ways is known by the machine down to the last half thousandth. Ferrite memory core can be programmed to compare actual position with required position as often as necessary and make the proper corrections. Two encoders furnish the position readout. One, operating directly on the lead screw, measures the pitch distance in 1024 parts. Since the pitch is a little over ½ in., this gives an accuracy of 0.0005 in. The other encoder is geared to make one revolution when the turret has moved about 12 feet. So the entire range of turret motion is covered with nonrepeating numbers measuring 0.0005 in. each.

Numerically controlled turret lathe with two memory units and turret position encoders is a product of the Warner & Swasey Co., Cleveland, Ohio.



Self-Optimizing Control Systems

Part 1—Basic Circuits

J. M. NIGHTINGALE
Manchester, England

The self-optimizing concept of servo design has been regarded generally as only an interesting "toy" for the theoretician. However, recent developments indicate that this advanced technique can be used with advantage in practical applications. An earlier article (January 7, 1960, pp. 139-143) gave a brief description of one type of self-optimizing servo circuit.

This current series of three articles will describe the system in more detail and discuss other similar systems. At points, fairly complex equations will be introduced to account for the actions within various loops. Happily enough, most of the solutions are produced automatically by the system.

FOR ANY optimized design of a control system, a figure of merit can be used as a measure of the performance ability of the system under various operating conditions. This figure of merit is required to be made either as small, or as large, as possible. In general, the figure of merit is an averaged positive measure of the error in the system. The mean-square of error is frequently chosen, primarily because it facilitates mathematical calculations.

Error Measurement: In continuously optimized systems, an instantaneous measure of the mean-square error must be made. For example,

$$E(\lambda,t) = \frac{1}{T}\int_{-\infty}^{t} e^2(\tau)^u \, d\tau \qquad (1)$$

where $u = -(t-\tau)/T$.

Equation 1 gives the measure obtained by passing the square of error through a filter having a simple time lag T. Time constant T must be long enough to smooth out random fluctuations, but not so long that excessive delay is required to detect transient

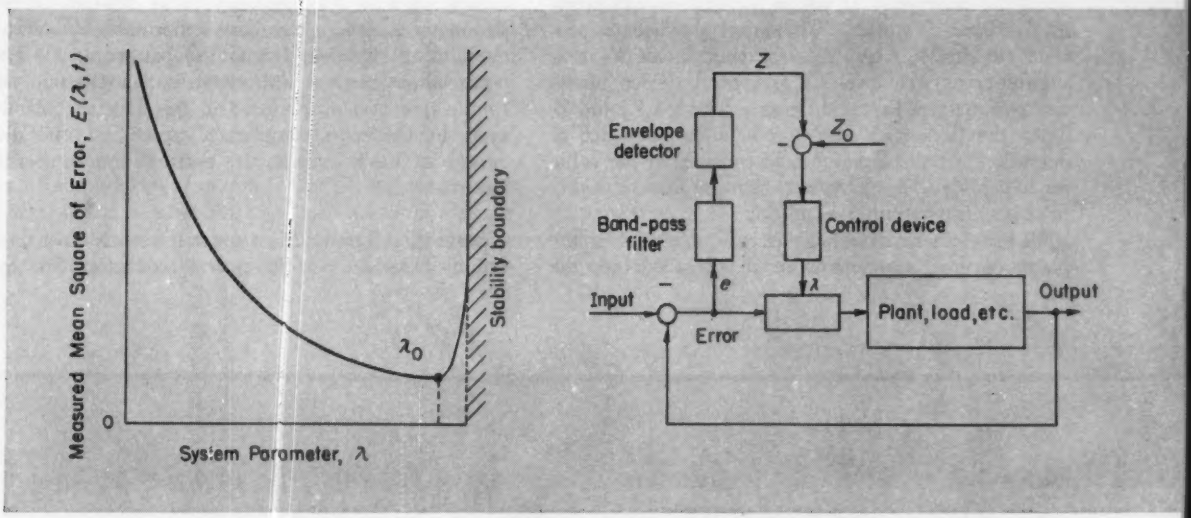


Fig. 1—When parameter λ controls the loop gain of a closed-loop system, the onset of instability in the system will impose an upper limit on λ. The optimum value of λ, given by the condition of minimum mean-square error, is near this limit.

Fig. 2—Block diagram of simple self-optimizing system for obtaining maximum gain. The band-pass filter is tuned to the frequency of oscillations.

changes in the error characteristics. The mean square of error, $E(\lambda,t)$ is a function of the control-system parameters, λ, and the input-signal characteristics.[1] General classes of signals having similar frequency distributions can be denoted by a spectral-density function, $\Phi(\omega)$. If the system input can be specified in this manner, $E(\lambda,t)$ will be largely independent of t, when steady-state conditions have been achieved.

The optimum setting for any parameter λ is given by the condition,

$$\frac{\partial E}{\partial \lambda} = 0$$

Self-optimizing systems which attempt to satisfy continuously this condition are in the general category of "extremum adaptive systems," as discussed by Aseltine.[2]

Parameter Evaluation: The adjustable parameter, λ, affects the scalar gain of a closed-loop system. The limit of λ because of the onset of instability in the control system will produce a curve as shown in Fig. 1. In this case, the position of the minimum of $E(\lambda, t)$ will be almost independent of the signal characteristics. The function of any self-optimizing

[1]References are tabulated at end of article.

Nomenclature

E	= Mean square of error
$E(\lambda,t)$	= Measured mean square of error
$e(t)$	= Control-system error
$e'(t)$	= Apparent error
H_c	= Transfer function of compensating network
$n(t)$	= Noise signal
s	= Laplace operator
T	= Time interval
t	= Time variable
$x(t)$	= Control-system input
Z	= Amplitude of oscillations
λ	= System parameter
τ	= Time delay
$\Phi(\omega)$	= Spectral-density function
ω	= Frequency variable

loop would then be to set the gain as high as possible without causing instability. An interesting method for achieving this result is described in Reference 3. The system can be represented by a block diagram, Fig 2. The band-pass filter is tuned about the frequency at which oscillations will occur in the control system. The envelope detector detects amplitude Z of the error oscillations; Z_0 is a suitable reference level. The control device monitors parameter λ by the difference between Z_0 and Z. Since the parameter loop has a closed sequence of operation, λ will be maintained constant at the value for which $Z = Z_0$. This value can be made suitably near to the optimum condition.

Such a system would be useful if changes in the plant or load characteristics drastically alter the value of λ required to just maintain stability. The filter must detect the frequency of oscillation. Since this frequency could change appreciably, good results might be difficult to achieve.

The perturbation method[1] does not have this difficulty, because the frequency to be detected in the parameter loop is a fixed one introduced by a small modulating signal added to the parameter λ. The perturbation method has some disadvantages in the simple type system discussed in this article.[4,5] However, in the more-complicated systems to be discussed in future articles, the perturbation method is essential.

Saturation Limits: Most control systems have saturation limits on certain system variables. For ex-

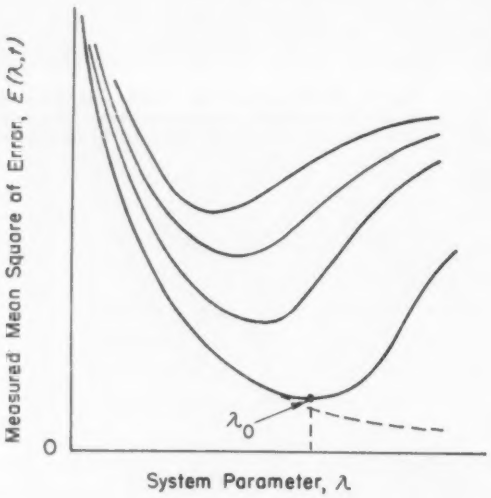


Fig. 3—When the control system contains a saturation element, the curves of mean-square error against gain λ may be of the form shown. The dotted curve shows mean-square error decrease if there were no saturation effect.

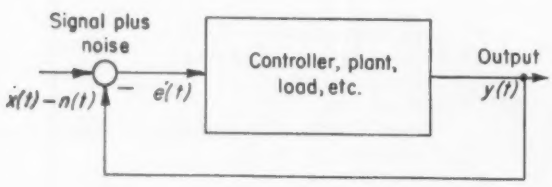


Fig. 4—In a closed-loop system with noise at the input, error $e(t)=x(t)-y(t)$ is not available as the input to a possible self-optimizing loop. Instead, the controller acts on an apparent error $e'(t)=e(t)+n(t)$.

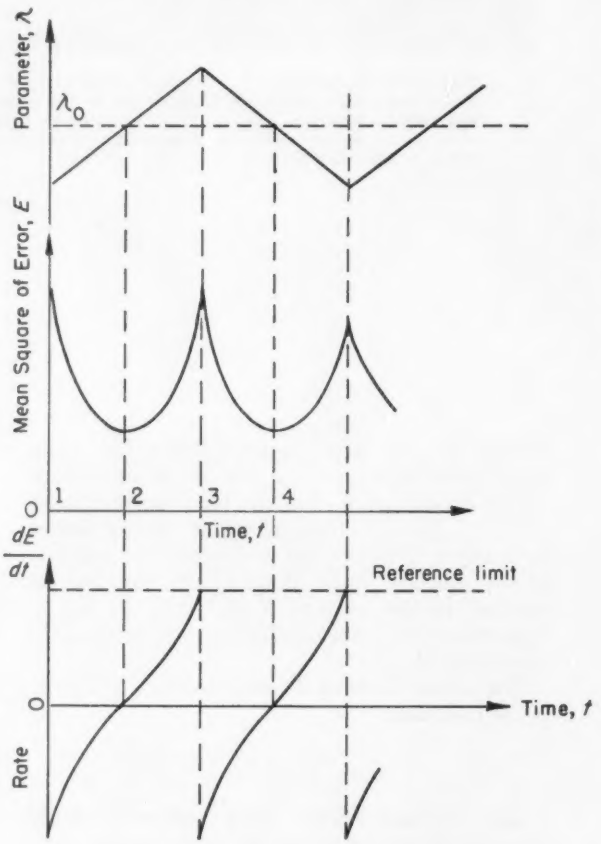


Fig. 5—Variation of parameter λ, mean-square error E, and the rate of change dE/dt for a system in which the direction that λ is being driven is reversed whenever dE/dt exceeds some fixed limit.

ample, the output torque and speed of a hydraulic motor are limited by the supply pressure and flow rate. The presence of such saturation characteristics produces a curve of mean-square error as shown in Fig. 3, when the gain λ of some linear element preceding the saturation element is varied. The optimum value of λ will vary considerably with signal characteristics. Hence, a self-optimizing loop can be used to compensate for changes in signal characteristics.

In many systems, some variables should be kept below prescribed limits even though there is no physical limitation on these variables. For example, the peak output acceleration of a servo motor may be restricted for safety reasons. This can be done, under stationary conditions, by choosing suitable compensating networks.[6] In general, the form of these networks will depend on the characteristics of the input signal. If these characteristics change, all the parameters of the compensating network must be altered. At best, this arrangement leads to a variable network in which the parameters depend on the single parameter, λ. For example, the transfer function of the compensating network might be of the form,

$$H_c = \sqrt{\lambda}\left(\frac{1+\lambda s}{1+\sqrt{\lambda}\, s}\right)$$

This network requires function generators or ganged-potentiometers.

Another solution to this problem induces limits on the specified variables by means of separate pa-

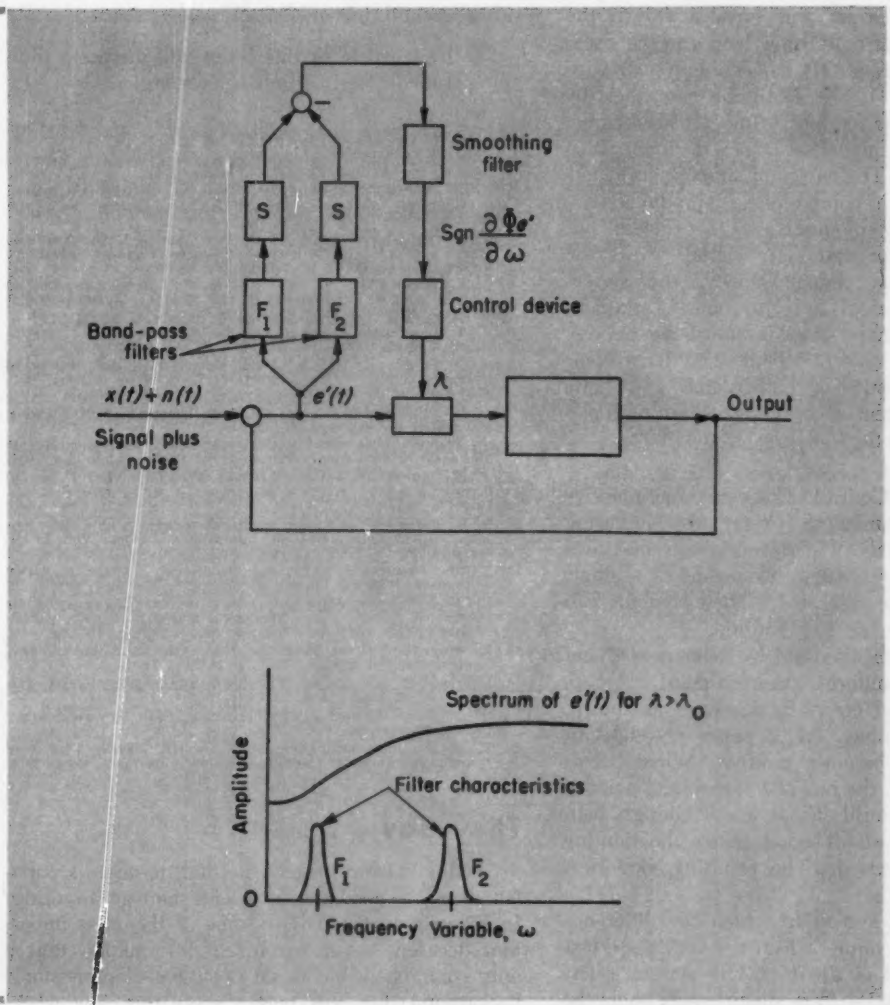


Fig. 6—In the system shown in the block diagram, the parameter loop acts on the apparent error. The system uses a special property of the spectral density function of the apparent error, in systems in which the noise has a uniform spectrum. The slope $\partial E/\partial\lambda$ depends on the slope of $\partial\Phi e'/\partial\omega$, which can be measured by filters having the characteristics shown.

rameter loops.[7] Such a system, using one constraint loop, is described in Reference 1. In these systems, one parameter λ is used to minimize $E\ (\lambda, t)$, and one other parameter is adjusted by each of the constraint loops. An applied perturbation is added to λ, and a perturbation of the same frequency is induced in each of the other parameters λ_1, λ_2, ... By this means, the minimum value of $E\ (\lambda_1, \lambda_2, \ldots)$ can be found. These multiple-parameter loops will be discussed further in future articles.

Many control systems are compromised by the presence of spurious external disturbances, commonly called noise. In some hydraulic servos, the effect of load disturbances can be conveniently removed by permitting leakage across the servo-motor supply. However, since the leakage reduces the dynamic response, a compromise must be made. Because the external disturbance is applied at the output, it is possible to measure true error $e\ (t)$ in the system. Thus, a self-optimizing loop can be used. Frequently the noise, $n\ (t)$, enters the system with the input signal $x\ (t)$, Fig. 4. In this case, the true error is not available for measuring. Instead, there is a corrupted error signal, $e' = e+n$, often called the apparent error. The choice of system parameters must be one which compromises reproduction of signal and filtering of noise. This problem has been investigated for stationary signals.[8,9] If the signal characteristics change slowly, the system parameters are adjusted to continuously minimize $E\ (\lambda, t)$. Systems have been proposed for making this adjustment.[10,11] Most of these systems compute the characteristics of both signal and noise and adjust the system accordingly. Future articles will discuss this method in greater detail.

Single-Parameter Control: The extremum-adaptive class systems minimize $E\ (\lambda, t)$ by measuring $\partial E\ (\lambda, t)/\partial\lambda$. Methods of performing this measurement by minimizing $E\ (\lambda, t)$ by means of a single parameter λ will be discussed. These systems can be externally driven or free running.

In the type system discussed in References 4 and 5, λ increases at a uniform rate from point 1, Fig. 5. The mean square of error, E, decreases as shown, and dE/dt is negative. As λ passes through λ_0, at point 2, dE/dt becomes positive. When dE/dt exceeds a fixed limit, the rate of λ is reversed, point 3; E again decreases until dE/dt again changes sign at point 4. When dE/dt again passes the limiting value, $d\lambda/dt$ is reversed. The resulting motion is hunting about λ_0.

Tsien discusses a system in which the difference between E and the value of E at the previous crossover is used instead of dE/dt.[12] This system is less sensitive to fluctuations from disturbances than the previous system. Various other "peak-holding" systems have been devised.

Other systems, [13,14,15] are based on free-running parameter loops. The variation, $\Delta\lambda$, in a parameter and the resulting variation, ΔE, in the mean-square error, which occur in a short time interval, are measured. Then, the sign of the quotient, $\Delta E/\Delta\lambda$, is used to make the necessary revision alterations in λ.

Burt[16] makes use of a special feature of the apparent error when the input to the control system is contaminated by noise of constant spectral density. The spectrum of the apparent error, e', increases or decreases with frequency when λ is less than, or greater than, the optimal value λ_0. That is,

$$sign\left(\frac{\partial E}{\partial \lambda}\right) = sign\left(\frac{\partial \Phi e'}{\partial \omega}\right)$$

The sign of $\partial\Phi e'/\partial\omega$ is measured by means of two band-pass filters which have similar amplitude characteristics but different center frequencies, Fig. 6. The mean-square outputs of the two filters are subtracted and the resulting signal gives a measure of $\partial\Phi e'/\partial\omega$ and thus of $\partial E/\partial\lambda$.

The next article in this series will discuss a multiple-parameter self-optimizing system.

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They Say . . .

"Today it is no longer true that, to quote a popular cliche, 'a good executive can manage anything.' In many areas of activity some of the most important decisions require technical information that is only comprehensible to an executive of professional background. For this reason every company whose products have a high engineering content has a responsibility—indeed, an absolute need—for developing managers from among its engineering staff."—J. LEE ATWOOD, *president, North American Aviation Inc., Los Angeles, Calif.*

Neutral Axes of Curved Beams

Here's a graphical method for speeding the design of curved beams having circular-segment cross sections.

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UNLIKE a straight beam, the neutral axis of a curved beam does not coincide with an axis through the centroids of the cross sections. Instead, the neutral axis pierces each section at a distance $O'N$ from the centroid, Fig. 1. The direction of the shift is toward the center of curvature, O, of the beam.

The magnitude of distance $O'N$ varies with beam curvature. The normal stress intensity of the inside fibers (of radius a) exceeds the opposite normal stress intensity of the outside fibers.

When the ratio of the radius of curvature of the beam to the depth of section ($R/2r$ for Fig. 1) is 6 or 5, the difference in stress intensities for the inside and outside fibers is on the order of 10 or 15 per cent. Whether this difference is great enough to justify the determination of $O'N$ in design calculations is largely a matter of opinion.

As the ratio of the radius of curvature to the depth of section diminishes below 5, the differences in stress intensities increase. For the circular section of Fig. 1 and $R/2r = 1$, the stress intensity in the inside fibers is more than twice that in the outside fibers. Accordingly, the stresses in any sharply curved beam-like member, as a hook, an eye in a

Nomenclature

a =	Inner radius of beam, in.
A =	Area of cross section, sq in.
c =	Outer radius of beam, in.
L =	A length such that $LR_N = A$, in.
N =	Position of neutral axis
O =	Center of curvature of beam
O' =	Center of cross sectional circle
r =	Radius of cross sectional circle, in.
R =	Distance of the center of cross sectional circle from the center of curvature, in.
R_N =	Distance of the neutral axis from the center of curvature, in.
$\angle$ =	Symbol for angle, radians

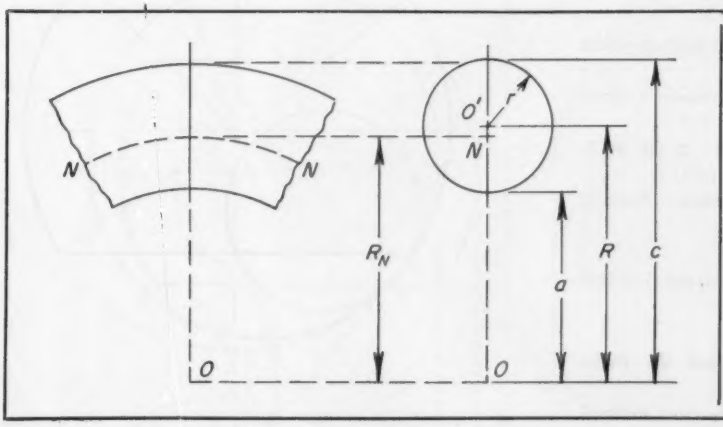


Fig. 1—Curved beam of constant circular cross section showing the position of the neutral axis and principal dimensions.

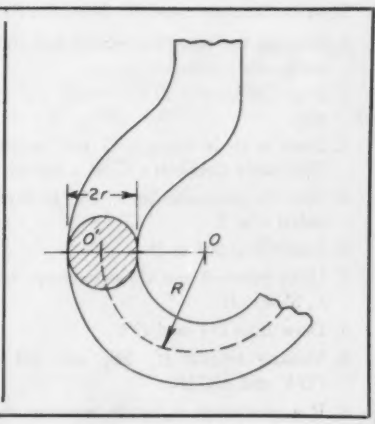


Fig. 2—Hook with a tapered circular cross section.

lug or tie bar, a U-bolt, or a chain link, are usually calculated according to the curved-beam theory. Hence, the position of the neutral axis must be determined. The labor required depends a great deal upon the complexity of the cross section.

The cross sections of many curved-beam members in machines or structures are circles and segments of circles. For such sections, distance $O'N$ can be found graphically.

The graphical method outlined here by examples is simple and accurate. It also provides a unique physical interpretation of the multiple-valued inverse trigonometric functions encountered in an analytic solution.

Example 1—Circular Cross Section

GIVEN DATA: Constant beam radius, $R = 4.500$ in., $r = 3.000$ in.

STEPS IN CONSTRUCTION: To determine R_N,

1. Describe the cross-section boundary by a circle of radius r with its center at O'; place the beam axis O at distance R from O'.
2. Draw OB tangent to the boundary circle.
3. Locate f from $Of = OB$.
4. Locate g from $Og = 2O'f$.
5. Locate h from $Oh = O'D' = r$.
6. Draw an arc of a circle tangent to Oh at h and passing through g to fix point N. The distance $ON = R_N$ ($= 3.92$ in., by measurement of a full-size drawing). Dimension R_N is the wanted radius to the neutral axis. When R_N is known, those dimensions of the beam needed for the calculations of stresses in the section are easily found, Fig. 1.

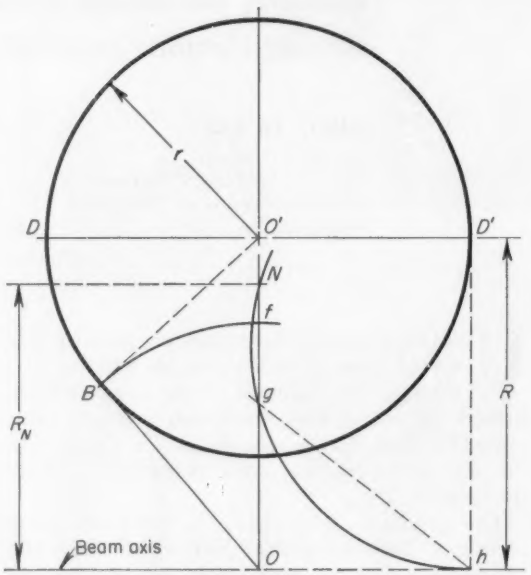
PROOF: The analytic solution* for the dimension R_N is

$$R_N = \frac{1}{2} r^2/[R - (R^2 - r^2)^{1/2}] \qquad (1)$$

From the diagram,

$$ON = R_N = \frac{r^2}{Og} \qquad (2)$$

*S. Timoshenko—*Strength of Materials, Part 2*, D. Van Nostrand Co., New York, second edition 1941, pp. 65-76.



$$Og = 2O'f = 2(OO' - OB)$$
$$= 2[R - (R^2 - r^2)^{1/2}] \qquad (3)$$

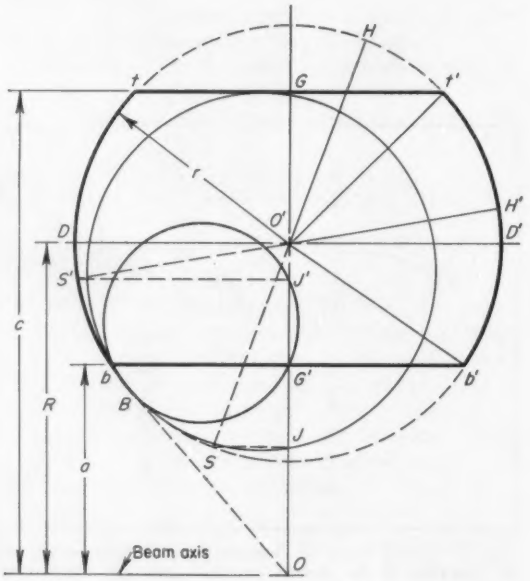
Equations 2 and 3 verify Equation 1.

Example 2—Unsymmetric Circular-Segment Section

GIVEN DATA: Constant beam radius, $R = 4.500$ in., $r = 3.000$, $a = 2.833$, and $c = 6.583$ in. This cross section consists of a circle cut by two straight lines bb' and tt'. The position of the neutral axis, R_N, is conveniently expressed by $R_N = A/L$.

STEPS IN CONSTRUCTION: To determine R_N,

1. Describe the boundary section and the position of the beam axis relative to it.
2. Draw OB tangent to the circular arc, extended if necessary.
3. Draw a circle through G and tangent to OB at B. This circle intersects OG at a second point J.
4. Erect JS perpendicular to OG to intersect a circle of radius r at S.
5. Extend line SO' to H.
6. Using points B and G', repeat steps 3, 4, and 5 to find J', S' and H'.
7. Draw lines $O't'$ and $O'b'$.
8. Measure lengths tt', bb', and OB and the angles $t'O'b'$ and $HO'H'$.
9. If a planimeter is handy, measure the cross sectional area, A. If a planimeter is not available, calculate the area from



$$A = (O'D)^2(\angle t'O'b') + \frac{1}{2}[(bb')(O'G') + (tt')(O'G)] \quad (4)$$

10. Calculate L from

$$L = tt' - bb' + 2(OO')(\angle t'O'b') - 2(OB)(\angle HO'H') \quad (5)$$

11. Find R_N as the quotient of the quantities found from Equations 4 and 5.

SOLUTION: From a full-size diagram, these measurements were made: $tt' = 4.25$ in., $bb' = 4.91$, $OB = 3.38$ in., $\angle t'O'b' = 1.372$ rad, $\angle HO'H' = 1.045$ rad, and $A = 20.63$ sq in. These measured values inserted in Equation 5 give $L = 4.623$ in. Thus $R_N = 20.63/4.623 = 4.462$ in.

PROOF: The analytic solution for length L is

$$L = 2[\{r^2 - (R-c)^2\}^{1/2} - \{r^2 - (R-a)^2\}^{1/2}] + 2R\left[\text{arc sin}\frac{c-R}{r} + \text{arc sin}\frac{R-a}{r}\right] - 2(R^2 - r^2)^{1/2}\left[\text{arc sin}\frac{Rc - R^2 + r^2}{rc} - \text{arc sin}\frac{Ra - R^2 + r^2}{ra}\right] \quad (6)$$

The terms within the first bracket of Equation 6 are equal to $tt' - bb'$. Those within the second bracket are equal to,

$$2R(\angle t'O'D' + \angle D'O'b') = 2(OO')(\angle t'O'b') \quad (7)$$

From the diagram,

$$O'J = R - \frac{R^2 - r^2}{c} \quad (8)$$

Hence,

$$\angle HO'D' = \text{arc sin}\frac{Rc - R^2 + r^2}{rc} \quad (9)$$

Similarly,

$$\angle H'O'D' = \text{arc sin}\frac{Ra - R^2 + r^2}{ra} \quad (10)$$

The remainder of Equation 6 is therefore equivalent to

$$2\,OB(\angle HO'D' - \angle H'O'D') = 2\,OB(\angle HO'H') \quad (11)$$

This completes a proof of the identity of Equations 5 and 6.

Example 3—Symmetric Circular-Segment Section

GIVEN DATA: Constant beam radius, $R = 4.00$ in., $r = 2.500$, $a = (R^2 - r^2)/R = 2.4375$, and $c = 2R - a = 5.5625$.

SOLUTION: For this symmetrical segment, $tt' = bb'$, and $\angle t'O'b' = \angle BOB'$. Equation 6 simplifies to

$$L = 2R(\angle BOB') - 2(R^2 - r^2)^{1/2}\,\text{arc sin}\frac{2Rr}{R^2 + r^2} \quad (12)$$

But

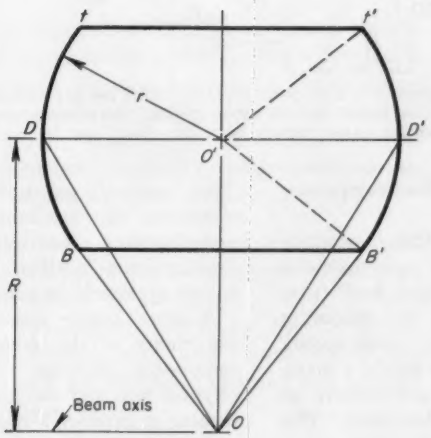
$$\frac{2Rr}{R^2 + r^2} = \sin(\angle DOD') \quad (13)$$

By measurement of a full-size diagram, $OB = 3.16$ in., $\angle BOB' = 1.353$ rad, $\angle DOD' = 1.120$ rad, and $A = 14.00$ sq in.

Hence,

$$L = 2[R(\angle BOB') - OB(\angle DOD')] \quad (14)$$
$$= 2[4.000 \times 1.353 - 3.16 \times 1.120] = 3.75 \text{ in.}$$

and $R_N = 14.00/3.75 = 3.73$ in.



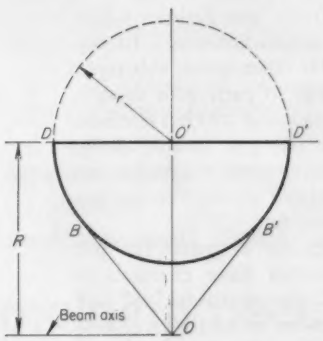
Example 4—Semicircular Cross Section, Case 1

In this case, Equation 5 degenerates into

$$L = -DD' + \pi R - OB(\pi - \angle BOB') = -DD' + \pi R - OB(\angle BO'B') \quad (15)$$

and

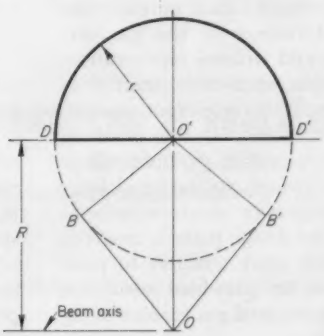
$$R_N = \frac{\pi r^2}{2L} \quad (16)$$



Example 5—Semicircular Cross Section, Case 2

In this case, Equation 5 degenerates into

$$L = DD' + \pi R - OB(\angle BOB' + \pi) \quad (17)$$



Gas Turbine Propulsion

How number and nature of loads affect gas turbine performance, and how gas turbines can supplement the output of conventional diesels.

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THE last ten years have witnessed an intensification of the effort to apply gas turbine powerplants to propel vehicles. To supplement this observation, this report is concerned, in part, with showing how the load and its characteristics can affect the gas turbine design and, in part, with suggesting another approach to the vehicle propulsion problem.

Gas turbines designed for propelling vehicles have characteristically used comparatively low compressor pressure ratios (3.5 and less), together with regenerative heat exchangers between the turbine exhaust gases and compressor discharge air. To determine the significance of changing the design compressor pressure ratio, examine the cycle performance of the gas turbine with and without regeneration. For a simple, open-cycle, shaft-power gas turbine, minimum specific fuel consumption (sfc) is obtained at high compressor pressure ratios.

A regenerated gas turbine using a low compressor pressure ratio at the full-load design point is observed to be much more sensitive to pressure losses at part-load condition than a regenerated gas turbine using a higher design, full-load compressor pressure ratio.

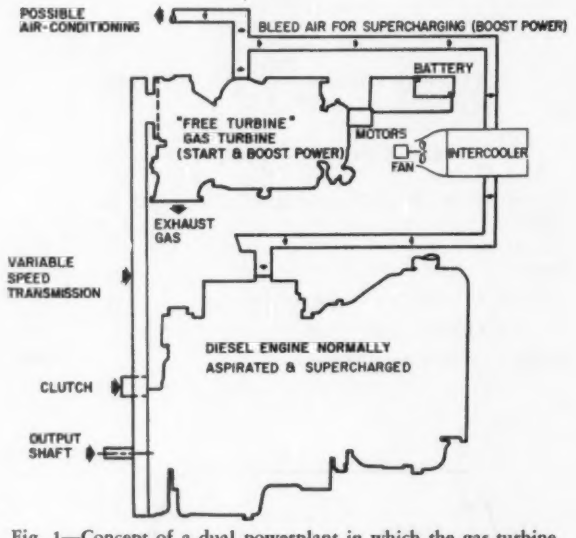

Fig. 1—Concept of a dual powerplant in which the gas turbine supplies starting power for the diesel engine. At subzero temperatures, turbine gases preheat both the diesel and its fuel.

It appears, too, that a control which will let the gas generator speed float with output load (that is, maximum load = maximum speed; lower load = lower speed) while maintaining as nearly a maximum turbine inlet temperature as possible would be desirable. The "free turbine" gas turbine, which eliminates the mechanical connection between the output power shaft and the "gasifier" power unit, is one approach to good control.

Another major consideration in the choice of the design full-load compressor pressure ratio is the physical size and weight of the gas turbine to produce a required horse-

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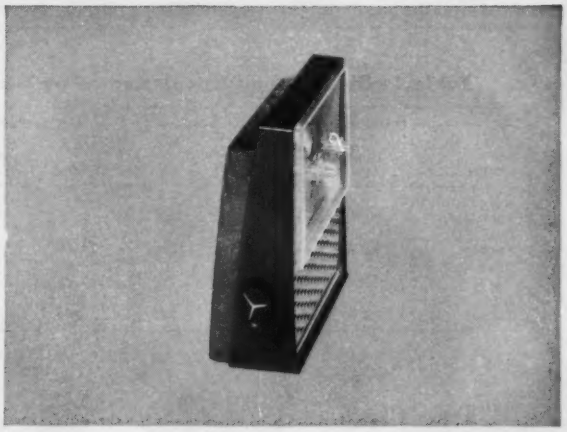

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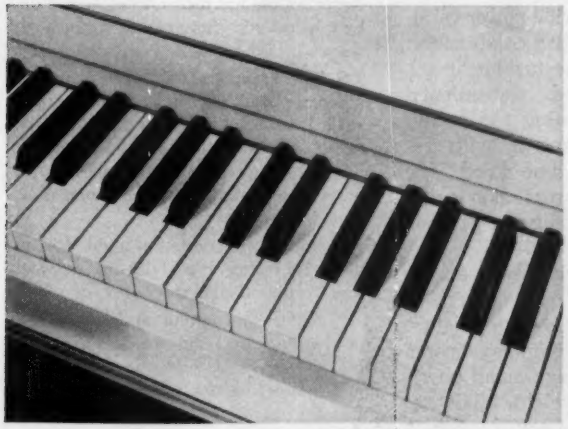

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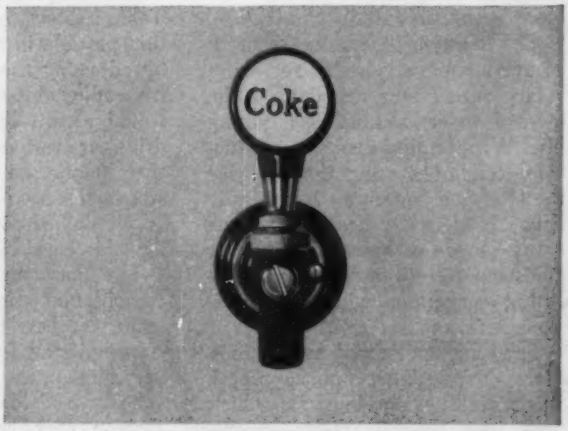

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Circle 464 on Page 19

Table 1—Diesel Output Supplemented by Gas Turbine

Diesel Power Output				Gas Turbine		
Air Charge	Bmep, (psi)	Bhp Per Cylinder	Four-Cylinder Bhp	Bhp	Bleed Airflow (lb/min)	Total Vehicle Bhp
Natural Aspiration	100	37.5	150	0	0	150
Low P/R Turbo	200	75	300	0	45	300
Inter P/R Turbo	250	95	375	125	55	500
High P/R Turbo	300	112.5	450	200	65	650

power. The increased size and weight of the gas turbine using a lower design compressor pressure ratio must also be taken into account in selecting the design full-load compressor pressure ratio.

The question of whether to use a recuperative heat exchanger or a rotary regenerator depends on the state of the art, as much as anything else. With improvements in production techniques using thinner gage materials, it appears theoretically that recuperative heat exchangers can be made as light in weight for the same over-all performance as rotating regenerators with their associated seals and leakage.

For some specialized applications, it even appears that a new approach might well be considered for vehicle propulsion whereby minimum specific fuel consumption can be achieved while utilizing a simple-cycle gas turbine's advantages. One that appears to have many attractive features consists of integrating the simple, nonregenerated gas turbine with a diesel engine. It is apparent that such an integration results in an efficient, versatile, lightweight, compact powerplant, Fig. 1.

In this dual powerplant, the gas turbine is used to supply the starting power for the diesel engine. At very low subzero temperatures, the gas turbine supplies hot gases to preheat the diesel engine and its fuel and then start it. The gas turbine can, of course, be started at very low temperatures with comparative ease, either electrically (using nickel-cadmium batteries, for instance) or by hand.

The diesel engine can then be used efficiently over its lower power range in a normally aspirated fashion, with the gas turbine not operating and declutched from the drive shaft. Additional power demands can be met by both clutching in the gas turbine to the drive shaft and using the gas turbine to supply pressurized air to the diesel engine (supercharging the diesel). Table 1 shows the wide power variation possible in such a combination by adjusting the gas turbine speed. An adjustable-speed transmission would permit operating the output drive at various speeds with respect to the gas turbine speed. The adjustable-speed transmission could be eliminated by using the gas turbine for bleed air only.

The gas turbine/diesel engine combination offers many other advantages besides low-temperature starting, good fuel economy over a very large power range, small physical size, and low weight. The gas turbine may be operated with a wide range of fuels, and since the turbine is available for starting the diesel, the reciprocating engine can accept a much wider range of multi-fuel usage.

SAE Paper 212C, "Gas Turbine Cycles and Design Concepts for Vehicle Propulsion," presented at the National West Coast Meeting, San Francisco, August 1960, 3 pp.

processes

Steel Casting and Steel Weldment Designs Compared

Harry R. Nara, head, Dept. of Civil Engineering and Engineering Mechanics; D. K. Wright, Jr., Professor of Machine Design, both of Case Institute of Technology; and Charles W. Briggs, Technical and Research Director, Steel Founders' Society

General conclusions from a comparative study of steel castings and steel weldments:

1. Normal structural parts, as produced in steel castings, are stronger under static loading than commercial weldments for a given design because of the higher carbon, manganese, and silicon contents in steel castings and, therefore, the generally higher tensile strength steel employed for castings. The steel for weldments is selected on the basis of its weldability, primarily, so that no stress relief or preheating need be done and the steel properties and carbon, manganese, and silicon contents are on the low side as compared to cast steel.

2. Steel castings generally have better fatigue properties than weldments for the corner designs studied.

3. Corner designs produced as steel castings resulted in lower stress concentration than existed in comparable designs as produced by fabrication welding.

4. Stress concentration factors for welded corners are dependent upon the particular shape attained by the weld fillet. Actual values are higher than those found by photoelastic examination of idealized shapes.

5. There appears to be no consistent difference between hand and machine welded corner design specimens or between as-welded and stress-relieved corner design specimens when these specimens are compared under comparable limited life tests.

6. Internal discontinuities did not reduce the fatigue life of casting or weldment corner design specimens.

7. Surface discontinuities in the region of the fillet area did reduce the fatigue life of both weldments and castings. In many cases the results were seriously affected.

8. The fatigue life and endurance limits of casting and weldment corner designs were of a similar order of values if the inside fillets of the structures were machined to the same inside radius.

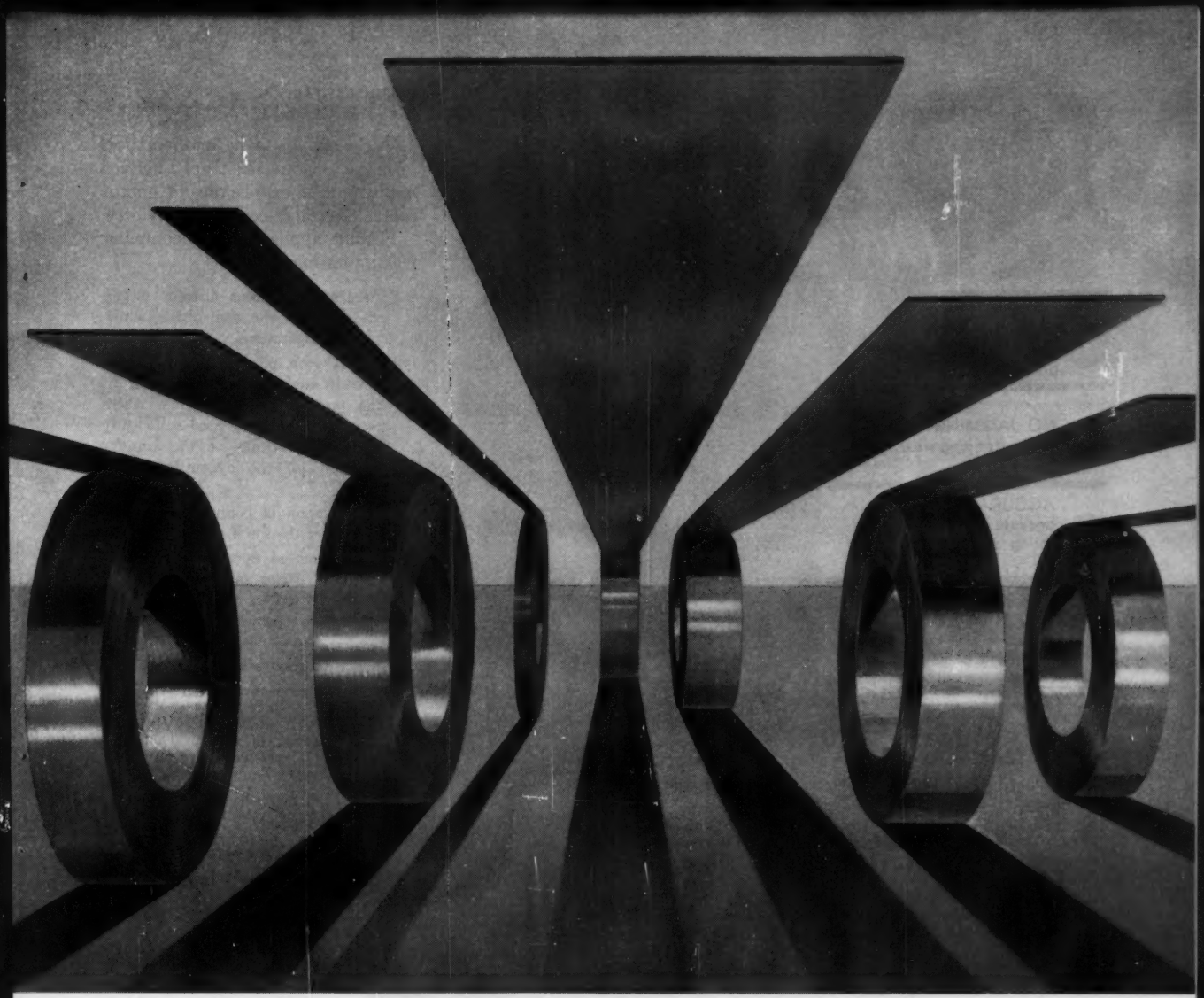
ASME Paper No. 60-SA-2, "Studies of the Design of Steel Castings and Steel Weldments as Related to Methods of Their Manufacture," presented at the Summer-Annual Meeting, Dallas, Texas, June, 1960, 19 pp.

mechanical

Possible Simulation of Human Dynamics and Perception

Anthony J. Cacioppo, head, Biomechanical Research, Avionics and Electronics Div., Goodyear Aircraft Corp.

Application of similitude theory and computer techniques to behavior science research. To translate the similitude concept to a useful tool and thus to bridge the gap between the conceptual and operational domains, two techniques are available: 1. Reduction of the dynamics of a



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Circle 465 on Page 19

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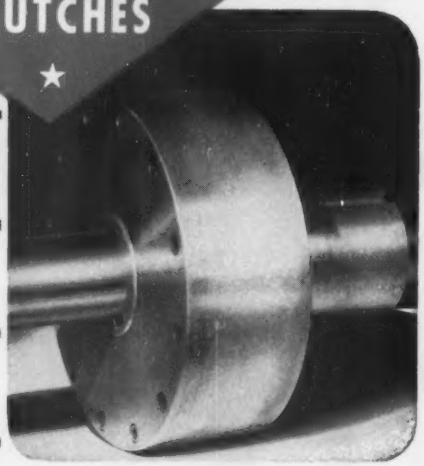

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physical system to its mathematical form. 2. Conversion of derived mathematical expressions to appropriate electronic-computer circuitry.

Possible applications for computer techniques may include:

1. Analyses of various aircraft, surface vessel, automobile, and submarine display configurations.
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3. Optimization of control systems, regardless of the specific type of vehicle.
4. Assessments of operator stresses encountered during space flight; for example, the effects of high or zero G loading on operator performance.
5. Assessments of information utilization in perceptual-motor tasks.
6. Person-interaction studies.

ASME Paper No. 60-AV-39, *"Possibilities for Simulation of Human Dynamics and Perception," presented at the Aviation Conference, Dallas, Texas, June,* 1960, 9 *pp.*

High Speed Tractor Steering Transmissions

H. W. Christenson, Allison Div., General Motors Corp.

In stating the steer problem, many factors must be considered: The turning resistance of the vehicle which is a function of the traction, vehicle geometry, centrifugal force, and rolling resistance; the turning effort couple which is the result of the imposed track forces; the type of turn; and the magnitude of steer effort forces.

Major track steering systems fall into two main groups: Differential steer and clutch brake steer. With differential steer, as the speed of one track is decreased the speed of the other track is increased. With the clutch brake system, one track is declutched and is usually braked to enforce a difference in speed to effect a steer.

In the evaluation of the two classes of steer systems, one important factor is the effect the two systems can have upon the input torque to the steer system when the vehicle, moving forward, is required to make a turn.

There are three principal advan-

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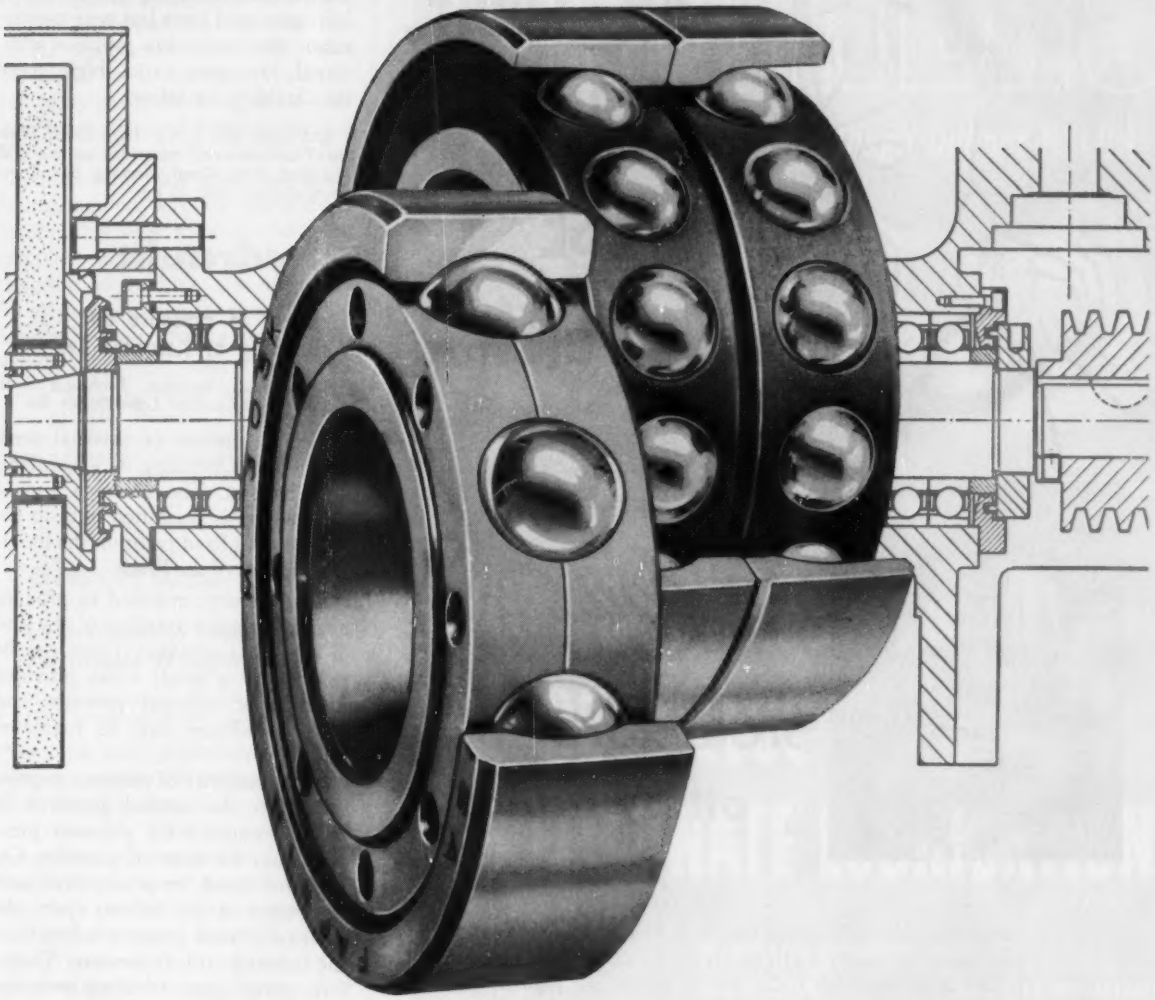

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Circle 467 on Page 19

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tages for geared steer in current transmissions: Components fit in less space and have less gear mechanism; steer reduction provides additional low gear ratio; high speed turn stability for safety.

SAE Paper No. 213C, "High Speed Tractor Transmissions," presented at the SAE National West Coast Meeting, San Francisco, August, 1960, 11 pp.

hydraulic

Effect of Pressure on Bending of Actuator Systems

Paul Seide, member, Technical Staff Space Technology Laboratories Inc.

Effect of internal or external pressure on the bending of a cantilevered bellows. The movable end of the bellows is permitted only to rotate about a fixed point on the longitudinal axis of the beam.

The moment required to produce a given angular rotation of the end of a bellows-actuator system can be reduced to a small value provided internal or external pressure and bellows stiffness can be regulated accurately.

The sensitivity of moment to pressure near the critical pressures is less pronounced for external pressure than for internal pressure. On the other hand, for pivot points near the center of the bellows span, the external critical pressure is less than the internal critical pressure. Therefore, given some working pressure, the use of an external-pressure system rather than an internal-pressure system would require either a higher bellows stiffness or a shift in the pivot-point location toward the ends of the bellows.

ASME Paper No. 60-APM-16, "The Effect of Pressure on the Bending Characteristics of an Actuator System," presented at the Summer Conference of the Applied Mechanics Division, University Park, Pa., June, 1960, 9 pp.

materials

Residual Stresses in Steels From Heat Treating Practices

E. T. Bergquist, Western Gear Corp., and S. M. Lenhoff, Ordnance Tank-Automotive Command, Army Ordnance Corps.

Correlation of residual stresses with existing industrial heat-treating

practices for various commercial steels. Specific purposes of tests were:

Results showed that optimum residual compressive stress (S_t value = 42,700 psi compression) was attained by gas-carburizing, slow-cooling, reheating, and brine-quenching 8620 steel. However, the S_t value obtained with this steel and processing method was not particularly outstanding over some of the other samples treated. Considering the program as a whole, the maximum difference between the highest and lowest S_t value was approximately 42,000 psi.

SAE Paper No. T-45, "The Effect of Material and Processing Variables on Residual Stresses in Carburized and Induction-Hardened Gears," presented at the SAE Summer Meeting, Chicago, June, 1960, 8 pp.

electrical

Electrochemical Fuel Cell For Ground Transportation

Morris Eisenberg, Missiles and Space Div., Lockheed Aircraft Corp.

Principles and possibilities of electric locomotion. Advantages are: 1. High starting torque. 2. Rapid acceleration. 3. Ease of control by controlling the magnetic field. 4. Simplicity of power transmission by electricity over mechanical methods.

The latter point makes it particularly convenient to employ four-wheel drive and to use the so-called electric wheel in which the hub of the wheel is the motor stator.

Since an electrochemical cell may be considered as the most efficient engine known to man, future trends in the development of these cells may be in the direction of combining them with nuclear energy.

SAE Paper No. 212B, "Electrochemical Fuel Cell for Transportation," presented at the SAE National West Coast Meeting, San Francisco, August, 1960, 6 pp.

TO OBTAIN COPIES of papers or articles abstracted here, write directly to the following organizations:

ASME—American Society of Mechanical Engineers, 29 West 39th St., New York 18, N. Y., papers 40 cents to members, 80 cents to nonmembers.

SAE—Society of Automotive Engineers, 485 Lexington Ave., New York 17, N. Y.; papers 50 cents to members, 75 cents to nonmembers.

Circle 469 on Page 19→

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Helpful Literature
for Design Engineers

For copies of any literature listed, circle Item Number on Yellow Card—page 19

Plastic Extrusions

New Bulletin 110 provides complete information and application engineering data on many types of plastic extrusions. Bulletin also shows typical applications and points out advantages that the use of plastic offers over other materials. Selection guide to thermoplastic compounds gives handy reference to the physical and chemical properties of thermoplastic compounds. 12 pages. Electric Storage Battery Co., Jessall Plastic Div., Kensington 4, Conn.

Circle 601 on Page 19

Aluminum Selection

Contained in illustrated Bulletin 30-1 are quick facts on aluminum coil, sheet, plate, tubing, pipe, rod, and bar available from stock, with guide to selection. Federal specifications, analyses, mechanical properties, tolerances, machinability ratings, finishes, corrosion resistance, and relative costs of aluminum alloys complete the data. 20 pages. Joseph T. Ryerson & Son Inc., Box 8000-A, Chicago 80, Ill.

Circle 602 on Page 19

Electrical Plugs, Connectors

New two-color brochure describes and illustrates complete line of Molded-On electrical plugs and connectors used on business and audio machines, and on general instrumentation equipment. Also included are line of patch cords for digital and analog computers, and line of custom moldings. Advantages of the various units are given. 6 pages. Components Mfg. Service Inc., West Bridgewater, Mass.

Circle 603 on Page 19

Lever and Tee Handles

New brochure describes handles for use on a variety of doors. Complete engineering data and cam drawings are provided for both types of handles, and features are pointed up. 4 pages. American Hardware Corp., Corbin Cabinet Lock Div., New Britain, Conn.

Circle 604 on Page 19

Bolt and Locknut

Two bulletins cover respectively LWB 922 12-point external wrenching bolt and FN 922 12-point featherweight locknut. Bolt-nut joint is rated at minimum tensile strength of 220,000 psi at room temperature and 170 000 psi at 900 F. LWB 922 bulletin includes complete dimensional information, tabulated mechanical properties of the bolt-nut joint, and a plot of tension-tension fatigue performance at both room and 900-F temperature. In addition to nut dimensional data, FN 922 bulletin includes a curve of torque versus induced load and size-by-size bar chart comparison. 4 pages each bulletin. Box 102, Standard Pressed Steel Co., Jenkintown, Pa.

Circle 605 on Page 19

DC Contactors and Relays

Bulletin GEA-6621A catalogs contactors and relays for all dc industrial control. It includes illustrations, layout and schematic diagrams, application data, and specifications for each line of general-purpose contactors, mill-type contactors, time-delay contactors, general-purpose and timing relays, and other relays. 32 pages. General Electric Co., Schenectady 5, N. Y.

Circle 606 on Page 19

Drawing Instruments

Illustrated Catalog 60-DI contains information on stainless steel and nickel-plated steel 6½-in. compasses and speed bow compasses, 4½ and 4-in. compasses and pen compasses, pen attachments, beam compasses and beam attachments, friction dividers, drop bow compasses, and a broad range of ruling pens. Special features of the instruments are pointed out. 6 pages. V. & E. Mfg. Co., 766 S. Fair Oaks Ave., Pasadena, Calif.

Circle 607 on Page 19

Welded Roll Design

"Studies in Applied Weldesign," No. 1204.1, provides information on the design of welded rolls. Many figures, tables, and examples are included, as well as material on stress in trunnion disc and angular tilt of trunnion disc. 6 pages. Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio.

Circle 608 on Page 19

Positive Seal

Type 500 Counterpoise seal is described in new bulletin. Springless in operation, it utilizes fluid pressure alone to close sealing faces during operation. Booklet provides drawings and text to explain operation, and lists advantages of the seals. 4 pages. A. W. Chesterton Co., 6 Ashland St., Everett 49, Mass.

Circle 609 on Page 19

Pumps and Motors

Two new two-color bulletins feature Series 15 Model H (Bulletin 100-P7) and Series 36 Model H (Bulletin 100-P6) fluid-power pumps and motors. Capabilities of the units are graphically illustrated with photographs, line drawings, and performance data charts. Other charts list a variety of flange mountings, port end covers, gear housings, drive shafts, and gear widths available in the series. 4 pages each bulletin. Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown 1, Ohio.

Circle 610 on Page 19

Tantalum Capacitors

"The Original Tantalum Capacitor," Bulletin 6.100-5, covers PP-type capacitors ranging from 325 to 1.75 mf, 6 to 125 v maximum working voltages for operation at 85 C at full ratings. Booklet contains specifications, performance characteristics, ratings, curves, and application data. It also includes a thorough description of capacitor seal design. 16 pages. Rectifier-Capacitor Div., Fansteel Metallurgical Corp., North Chicago, Ill.

Circle 611 on Page 19

Plastics Products

Revised, liberally illustrated Bulletin D 400 covers diversified line of plastics products designed for a wide range of industrial applications. Text is supplemented by photos showing 35 typical products applications; a representative materials selection guide on 22 molding compounds of six different types, encompassing choice of materials, recommended uses, design advantages, and properties; and a similar properties-application chart for Hetron resins. 8 pages. Durez Plastics Div., Hooker Chemical Corp., 8 Walck Rd., North Tonawanda, N. Y.

Circle 612 on Page 19

Toggle-Switch Assemblies

Data Sheet 174 describes Series 400 tab-indicator toggle-switch assemblies. Paddle-shaped tab of clear anodized aluminum enables easy identification of lever position. Features and dimensional data are given. 2 pages. Micro Switch Div., Minneapolis-Honeywell Regulator Co., Freeport, Ill.

Circle 613 on Page 19

Polypropylene

Technical Data Booklet AP-601 describes polypropylene, providing information on features, characteristics, injection molding, and extrusion. Colorful section shows many applications of the light plastic. Final section gives data on how to color, finish, and form the material. 12 pages. Avisun Corp., Post Road, Marcus Hook, Pa.

Circle 614 on Page 19

With Extras . . . At No Extra Cost

1. METAL PISTON ROD SCRAPER—protects rod packing, cylinder bore and rod surface by removing all foreign particles.
2. NEW "SUPER" CUSHION for air or METALLIC SELF-ALIGNING MASTER CUSHION for oil.
3. HARD CHROME PLATED CYLINDER BORES AND PISTON RODS for greater protection and reduced wear.
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8. STREAMLINED DESIGN . . . operating pressures to 200 PSI, air; 1,000 PSI oil, non-shock.

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The T-J Spacemaker eliminates tie-rods, gives greater strength, saves space . . . and reduces costs in all push-pull operations. Immediate delivery in a complete range of styles and capacities . . . air or oil. Write for Bulletin SM 155-4, today. The Tomkins-Johnson Company, Jackson, Michigan.

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RIVITORS . . . AIR AND HYDRAULIC CYLINDERS . . . CUTTERS . . . CLINCHORS

Circle 470 on Page 19

Solid Lubricants

"What is Molykote?" covers theory and practice of lubrication by solids. Pocket-sized Bulletin 124 discusses boundary friction and the role of solid lubricants to reduce friction and wear under heavy loads and at high temperatures. The major advantages of molybdenum disulfide solid lubricants are described. 24 pages. Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Circle 619 on Page 19

Phosphor Bronze

In addition to a detailed explanation of continuous casting, revised technical handbook includes information on phosphor-bronze wire, bars, rods, strip, sheets, circles, and special shapes. Flexograin, a special fine-grain phosphor bronze, is also discussed in detail. Complete specifications on six phosphor-bronze alloys are given in an easy-to-read format. 18 pages. Riverside-Alloy Metal Div., H. K. Porter Co. Inc., Riverside, N. J.

Circle 618 on Page 19

Flexible Tubing

"The Facts About Flexible Tubing," Catalog 10-19, provides a full description of the varied forms, major advantages, and uses of flexible tubing. Tubing is basically a synthetic material or fabric cover supported by a coiled spring. Material is treated cotton, glass fiber, Dacron, nylon, or some other, depending upon application. There are many variations and sizes. 4 pages. Flexible Tubing Corp., Guilford, Conn.

Circle 617 on Page 19

Back-Up Rings

Catalog 5482 is a design and data booklet on Parbak back-up rings. Catalog shows how to increase O-ring life, seal higher pressures, and reduce costs. Also included are design data, sizes, dimensions, and compound information. Liberal use of tables and line drawings is made. 8 pages. Parker Seal Co., Div., Parker-Hannifin Corp., 10567 Jefferson Blvd., Culver City, Calif.

Circle 616 on Page 19

Synchronous Motors

Slo-Syn Data Sheet 1 gives explanation of the use of Slo-Syn synchronous motors as dc stepping motors. It explains and shows stepping principles of permanent-magnet motors, and contains diagrams and speed-torque characteristics charts. Details of bifilar motors are described also. 4 pages. Superior Electric Co., Dept. SS, 83 Laurel St., Bristol, Conn.

Circle 615 on Page 19

Power Cylinders

New bulletin provides data on stock air and hydraulic power cylinders. Strokes, dimensional data, and prices on the expanded stock selection are given, as well as prices and dimensions on stock clevises, clevis and eye brackets, eyes, and pins. Cylinder variations, such as rotated ports, rotated cushion adjustments, rod extensions, mixed mountings, and piston ring and/or Teflon piston cup seals, are listed. 4 pages. Miller Fluid Power Div., Flick-Reedy Corp., Bensenville, Ill.

Circle 620 on Page 19

Quick-Disconnect Couplings

Two-color catalog describes a line of fluid, self-sealing, quick-disconnect couplings. Seven basic series of Inst-O-Matic connectors are covered, with particular applications of each series given. Special section contains a table of condensed seal recommendations for many fluids. Pressure-drop curves are also illustrated. 16 pages. E. B. Wiggins Oil Tool Co., Inc., 3424 E. Olympic Blvd., Los Angeles 23, Calif.

Circle 621 on Page 19

High-Strength Bolt

Savings up to 40 per cent in bearing-type connections can be achieved through use of a high-strength bolt described in a new bulletin. Larger head and shorter thread length of the bolt design offer substantial advantages. Bulletin also contains excerpts from the latest ASTM specification for A325 bolts for structural joints. 4 pages. Russell, Burdsall & Ward Bolt & Nut Co., 100 Midland Ave., Port Chester, N. Y.

Circle 622 on Page 19

RTV Silicone Rubbers

Publication S-3 provides product and application data on RTV silicone-rubber compounds. Included is information on RTV-11, new, low-viscosity liquid silicone-rubber compound. Booklet also contains additional information on thermal conductivity compression set, and an expanded section providing new data on heat aging and electrical properties. Featured are suggestions for handling RTV compounds, curing and viscosity characteristics, and information on RTV primers for bonding applications. 12 pages. Silicone Products Dept., General Electric Co., Waterford, N. Y.

Circle 623 on Page 19

Plastic Cabling and Circuitry

Bulletin S-9 is a plastic cabling and circuitry guide which includes design features, specifications, and applications for multiconductor flat wire cable, multilayer circuitry, and flexible etched cable, circuits, and laminates. Advantages of the various units are pointed out, as well as constructions available. 8 pages. International Resistance Co., 401 N. Broad St., Philadelphia 8, Pa.

Circle 624 on Page 19

Silicones for Automotive Use

"Silicones for the Automotive Industries," Reference 1-118, describes how silicones in various physical forms help designers of autos, trucks, and other land vehicles solve difficult engineering problems. Applications for silicone products in production equipment and as aids to manufacturing and maintenance are also outlined. Reference explains how the properties and forms of silicones combine to make possible new concepts and new freedom in design engineering. 8 pages. Dow Corning Corp., Midland, Mich.

Circle 625 on Page 19

Relays and Timers

Catalog K includes information on power relays, small relays, sensitive, latch, sequence, industrial, and instrument-controlled relays. Also contained are data on timers, special-purpose units, mounting covers, and housings. Pictures and tables describe each unit and provide specifications. Page on selection of relays is incorporated. 40 pages. Struthers-Dunn Inc, Pitman, N. J.

Circle 626 on Page 19

TFE-Fluorocarbon Shapes

Bulletin BR-4 describes full line of Polypenco Teflon (TFE-fluorocarbon) stock shapes and fabricated parts. Complete physical property tables and representative applications for rod, tubing, tape, and sheet are included. A separate section is devoted to Fluorosint, a new TFE-fluorocarbon-base composition. 8 pages. Polymer Corp. of Pennsylvania, 2140 Fairmont Ave., Reading, Pa.

Circle 627 on Page 19

Properties of Plastics

Pocket-sized booklet compares outstanding properties and typical industrial applications of 13 major plastic families in common industrial use. Included are acrylic, Implex, nylon, Teflon, polyethylene, flexible and rigid vinyl, cellulose acetate, butyrate, polystyrene, high and medium-impact styrene, phenolic, and glass-fiber-reinforced polyesters and epoxies. Others are Mylar, ABS, and acetal. Five major misconceptions about plastics are corrected. 6 pages. Cadillac Plastic & Chemical Co., 15111 Second Ave., Detroit 3, Mich.

Circle 628 on Page 19

Test Equipment, Panel Meters

Catalog 28/Industrial contains information on precision electronic test equipment and panel meters for industrial maintenance and communications. Included are volt-ohm milliammeters, vacuum-tube voltmeters, tube and transistor testers, sine and square-wave generators, oscilloscopes, and panel meters. All specifications are given for the various units. 20 pages. Write on company letterhead to Precision Apparatus Co. Inc., 70-31 84th St., Glendale 27, L. I., N. Y.

Semiconductors

Catalog SC360 includes basic specifications on line of VHF transistors manufactured by post alloy diffusion process for converter, mixer, and oscillator applications. Catalog also contains a listing and specifications on a line of germanium PNP and NPN audio, computer, and switching transistors. Also listed are lines of germanium and silicon reference and power-rectifier types, and photodiodes. 12 pages. Write on company letterhead to Amperex Electronic Corp., 230 Duffy Ave., Hicksville, L. I., N. Y.

The most efficient compressed-air-line filter you can buy...

New, perfected-design Norgren Air-Line Filters give you these benefits:

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Norgren Filter removes all liquid from compressed air

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New, stronger transparent bowl is an important feature of the new filters. This bowl has a higher safety factor than ever before and a much greater resistance to fatigue.

The bowl has a larger capacity for collected liquid. The "quiet zone" below the baffle holds 53% more collected air-line contaminants—requires less frequent draining.

Servicing is easier and quicker. No tools are required to disassemble the filter for cleaning, and there are only four separate parts to handle.

For complete information about the money-saving features of the Norgren complete line of manual drain and automatic-drain filters, call your nearby Norgren Representative, listed in your telephone directory—or **WRITE FOR BROCHURE NA-1.**

Circle 471 on Page 19

New Parts and Materials

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Miniature Clutch

has minimum torque rating of 10 oz-in. at speeds to 1000 rpm

Model 162 high-efficiency miniature magnetic clutch drives potentiometers, servo balance units, remote controls, and speed changers. It has minimum torque rating of 10 oz-in. at speeds to 1000 rpm, and is available in four voltage ranges, all operating at 2.5 w. Unit occupies about 1 cu in. Torque loss with

stainless ball bearings is less than 0.3 oz-in. Field shaping and steel-to-brass clutch face enables clutch to deliver up to 15 oz-in. to the load at 2.5 w. Model 162 operates to 85 C and withstands severe humidity, shock, and air pressure. **Ultronix Inc.**, 111 E. 20th Ave., San Mateo, Calif.

Circle 629 on Page 19

PVC Ball Valves

have high impact strength

Ball valves of Type I unplasticized polyvinyl chloride are dimensionally stable with very high impact strength. Nontoxic, nonflammable, and almost completely nonaging, valves can be heat welded or solvent bonded in the line for maximum integrity. Temperature range permits service to 140 F. Valves are rated at 125 psi, and extreme light weight makes them suitable for use

on long, unsupported spans of plastic and other pipe. Designed with Teflon seats, valves give full flow when open and are completely leaktight when closed. Positive stops indicate full-open and full-closed positions. Installation is simplified by coupling-like assembly which permits each half of the valve to be fitted to the pipe ends, and then reassembled. Units are available initially in ½, ¾, and 1-in. sizes with all NPT female connections. **Hoke Inc.**, 1 Tennakill Park, Cresskill, N. J.

Circle 630 on Page 19

Tab Mount Light

for exterior mounting on panels and dashboards

Tab mount light provides controlled, nonglare illumination using scientifically designed prisms. By varying the angled faces of these internal prisms, an exact pattern of illumination is obtained. Light "spill-over" is eliminated, avoiding eye-strain and fatigue. Unit is espe-

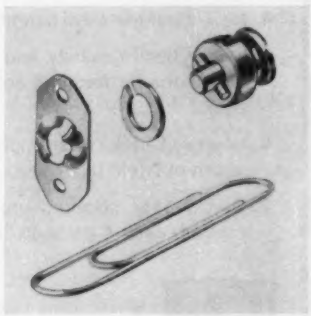
cially designed for exterior mounting on instrument panels, control panels, and dashboards. It also allows maximum flexibility in location mounting on instruments and panels. One 6-32 screw or rivet is required for mounting. Over-all length of the light is approximately ¾ in., and it is available in 6, 14, or 28-v models manufactured in accordance with aircraft standards. **GlarBan Corp.**, 108 Glar-Ban Bldg., 3807 Harlem Rd., Buffalo 15, N. Y.

Circle 631 on Page 19

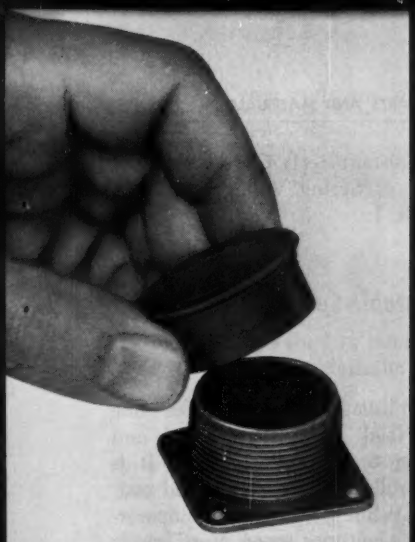
Quick-Release Fastener

subminiature unit has high clamping force

Series 12F subminiature, quarter-turn, quick-release fastener is available for light covers, small subassemblies, and miniature black boxes. It provides a high clamping force



with an ultimate tension-shear rating of 150 lb in minimum envelope dimensions. New receptacle design provides reduced size with ½-in. rivet spacing, yet uses standard 0.062-in. diam rivets. Spring design in the stud assembly provides superior reach characteristics not possible with designs using spring-type receptacles. Stud assemblies are available in length increments of 0.015 in. to insure adaptability to all grip-range requirements. Fastener is available in both carbon and corro-



product saving protection

eye appeal that adds sales appeal

quickly applied... and removed

won't chip, break, shred or collapse

save time, trouble and $$$

Caplugs

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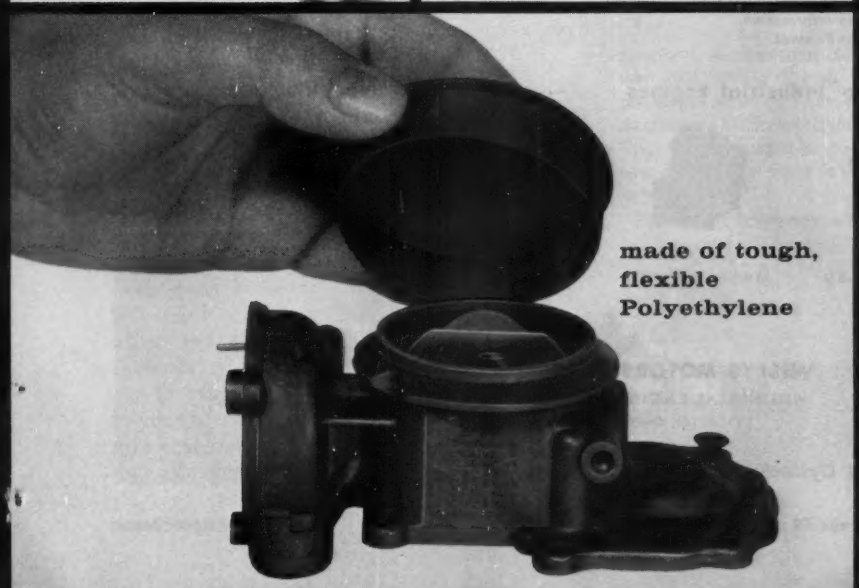

made of tough, flexible Polyethylene

"kid glove" protection for tubing, threaded fittings and machined parts in process, storage and transit... get a kit full of samples in exchange for the coupon below.

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Circle 472 on Page 19

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Whatever the equipment you design, in the final analysis it must *sell* to be a success. And this is exactly how 'Jeep' Industrial Engines can help you. Not only do they have the stamina for continued top performance, but they enjoy an unusually wide consumer acceptance...to give you *more selling muscle!*

PROVEN RUGGEDNESS The proven-in-action 'Jeep' Engine is known throughout the world as a tireless warrior. 'Jeep' Industrial Engines are designed specifically to meet today's demanding needs.

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WILLYS MOTORS, INC.
INDUSTRIAL ENGINE DEPT.
TOLEDO, OHIO

Manufacturers of 'Jeep' -4 and -6 Cylinder Industrial Engines

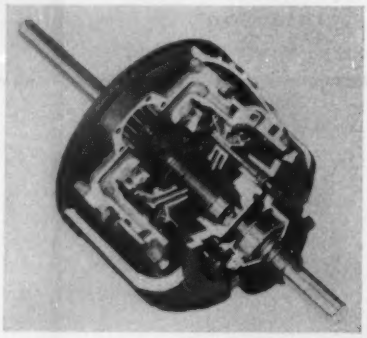
sion-resistant steels. **Camloc Fastener Corp.**, 37 Spring Valley Rd., Paramus, N. J.

Circle 632 on Page 19

Adjustable-Speed Drive

operates at both constant and adjustable speeds

VariDraulic engine operates one work load at constant speed and another at adjustable speeds. It is a controllable hydrostatic fluid coupling. While power source is operating at a constant speed, VariDraulic



enables power to be applied smoothly to the load and varied to suit load requirements as to speed or torque. Unit provides a flexible, shockfree speed control between power source and work load. Gears are positive, oil smooth, and each unit is self-contained with no external plumbing. Drive is available in a wide range of sizes and standard packages, or with special shafts, housings, and controls to suit specific requirements. **Hydraulics Inc.**, 1727 South Blvd., Parsons, Kans.

Circle 633 on Page 19

Turns-Counting Dial

has internal illumination

Series 1330 direct-reading digital microdial, designed for both military and commercial applications, combines digital counting system with internal illumination for improved readability, new exterior design, and choice of five standard color combinations. Unit counts from 000 through 999 in exactly ten turns. Rotation is continuous for standard models. A finger-tip brake is optional. Numbers are displayed through a sealed, one-piece lens with about 1.5X magnificatior. for im-

Circle 473 on Page 19

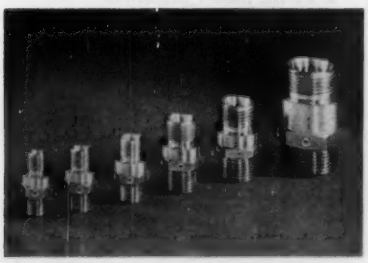
proved readability. Curved design of lens permits wide-angle viewing. Internal illumination is available in white light or in red light for use in dark-adapted environments. Adjustment knob is machined aluminum with a fluted rim for sure grip. Front of cap of the dial is plastic and of snap-on design, permitting easy access for lamp replacement. Unit is completely sealed against dust and moisture. Over-all size is 1¾ in. diam, 1¾ in. high; numerals are 3/16 in. high. **Borg Equipment Div., Amphenol - Borg Electronics Corp.**, 120 S. Main St., Janesville, Wis.

Circle 634 on Page 19

Miniature Check Valves

for high-pressure hydraulic applications

Miniaturized check valves are made in ¼ through 1-in. OD tube sizes with flared or flareless tube fitting ends. Designed for high-pressure hydraulic applications in aircraft, missiles, ground-support equipment, test stands, and consoles, valves have a rated operating pressure of 3000 psi, with zero leakage. Other specifications are: Proof pressure, 4500 psi; burst pressure, 7500 psi; cracking pressure, 2 to 8 psi; internal leakage, zero at 1000 psi, 3 cc per hr at 5 psi. Temperature range is −65 to +50 F. Flow ranges from 1.2 gpm for ¼-in. size to 29 gpm for 1-in. size, with pressure drops well be-



Why "MARK-TIME" MECHANICAL TIMERS should be INVESTIGATED!

Low cost mechanical Timers, Time Switches and Time Devices **can** be quite sophisticated. For example: they can be designed to ring bells, flash lights, turn valves, cut cords, start, stop or operate electrical or mechanical equipment, and to do all this **after** a pre-selected time period has elapsed.

The "Mark-Time" mechanical "memory" **cannot** fail due to an electrical failure since it is spring powered.

The "HEART" of the "Mark-Time" is of a new super-tough alloy which prolongs mainspring life indefinitely.

This new special steel virtually **eliminates** mainspring failure. This adds extra sales features to your product at no extra cost.

The "MARK-TIME" Mainspring is Unbreakable!

Tensile strength, durability and corrosive resistance is unexcelled. No other Timer on the market has these exclusive features.

At present, we manufacture more than 3,000 DIFFERENT kinds of custom-built timers for industrial, consumer and military applications. Thus, we are the **largest** manufacturer of mechanical timers in the **world**!

Research and development work welcome—small runs our specialty.

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Write for your copy of this **new** Engineering Handbook on Timers, specifically written and illustrated for the Design and Development Engineer.

MARK-TIME

M. H. RHODES, inc.

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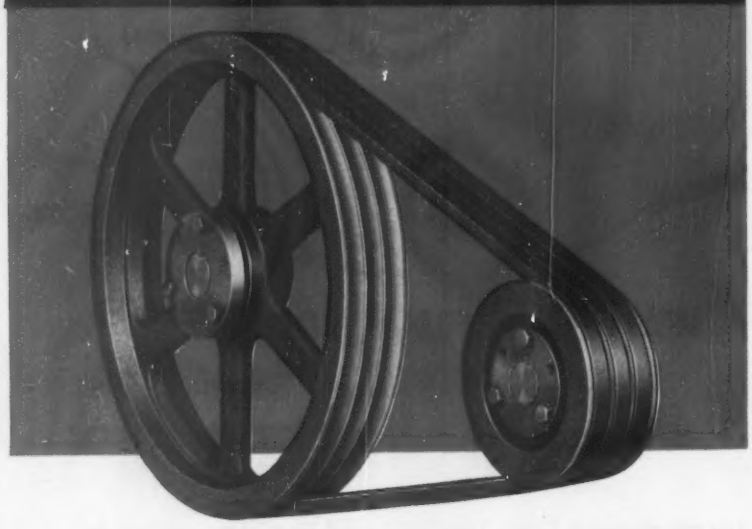
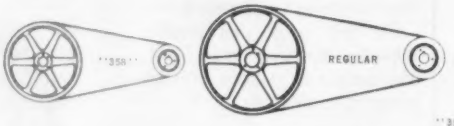
Circle 474 on Page 19

Browning "358" GRIPBELT DRIVES



The "358" Gripbelt is narrower and deeper

than regular types, providing efficient, more compact V-drives 

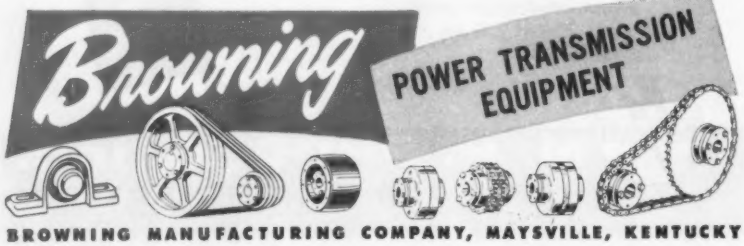
with fewer belt cross sections

and all

top-quality features

Investigate. See your Browning Distributor. Catalog V-358-B.

Browning POWER TRANSMISSION EQUIPMENT



BROWNING MANUFACTURING COMPANY, MAYSVILLE, KENTUCKY

Circle 475 on Page 19

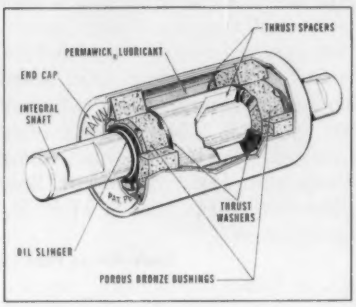
low the 15-psi specification limit. Stainless steel is the standard material for the valves; they can also be furnished in other materials. **Weatherhead Co.**, 300 E. 131st St., Cleveland 8, Ohio.

Circle 635 on Page 19

Shaft-Bearing Assembly

has long life expectancy

Shaft-bearing assembly is recommended for applications where bearing noise or conducted resonances are problems. Absence of internal vibration makes the bearing suitable for use in home and industrial power tools. Sealed bearing has a



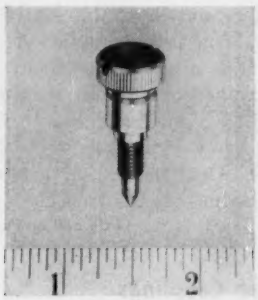
lifetime recirculatory oiling system, will not leak oil, and is highly resistant to invasion by dirt or moisture. Base life of at least 20,000 hr is expected. Unit is designed primarily to handle nominal loads at moderate to high speeds. Bearing is presently available with an ID of 1.181 in. and a shaft diameter of 0.4995 in., in lengths to 6 in. Current assembly handles radial loads of 25 to 30 lb at speeds of 500 to 4000 rpm with moderate thrust loads. **Tann Bearing Co.**, 2741 E. Congress St., Detroit 7, Mich.

Circle 636 on Page 19

Panel Screw

for 1/16, 1/8, and 3/16-in. panel thickness

Captive panel-screw assembly, No. 1805, is corrosion-resisting steel, class 303, per QQ-S-763b, with a No. 10-32 NF-2 thread. Head of screw is polished and slotted with a medium straight knurl side and passivated finish. Captive panel-screw bushing is brass per QQ-B-626a, Comp. 22½ hard, finished



with light polish and 0.0005-in. nickel plate. Assembly is available for panel thickness of 1/16, 1/8, and 3/16 in. **Cambridge Thermionic Corp.**, 445 Concord Ave., Cambridge 38, Mass.

Circle 637 on Page 19

High-Carbon Steel Wire

has tensile strength of 575,000 psi

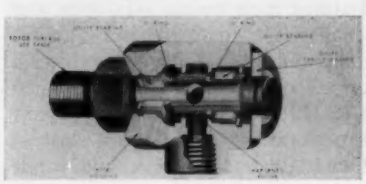
High-strength wire with 575,000 psi tensile strength is a high-carbon steel wire (approximately 0.90 per cent carbon), available in 0.005-in. diam and finer. Larger sizes will be available with slightly reduced tensiles. Wire is available with brass finish in continuous lengths to 2 lb and on spools to 10 lb. Initial uses have been in fabrications with plastic binders to form high-tensile members for military applications. **National-Standard Co.**, Niles, Mich.

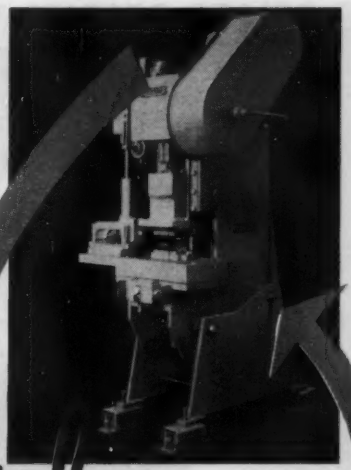
Circle 638 on Page 19

Rotating Union

is slow-speed air or hydraulic unit

Slow-speed, low-cost air or hydraulic union for single-passage applications, Model 15, incorporates two Oilite bearings to eliminate radial load which may be applied to the O-rings. With hose entrance between the O-rings, any thrust due to line pressures is balanced. Since thrust and radial loads are at a minimum, greater O-ring life is obtained. Union is suited for installations where shaft speed is not over





NEW!

Circulube

by BIJUR

A system of centralized, completely automatic machine lubrication with provisions for oil return

This new system continuously circulates clean, filtered oil through machine bearings at controlled rates. It also provides for filtering and removing contaminates from returned oil before recirculation.

WHAT IT DOES

Oil is pumped to bearings through the system, and returned through tubing or piping as advised by Bijur's engineering staff. Control-Units, installed at each bearing, control the flow of oil to that bearing.

Model CLFC has a dual pump which also permits cyclic oil delivery to certain bearings.

HOW IT WORKS

Basically, the Circulube system consists of a lubricator pump with reservoir and filter, a distribution system, and the control units at each bearing. The "brain" of the system is the Pressure Signal Switch. It prevents machine operation until proper oil pressure has been developed.

EXCEPTIONAL EFFICIENCY

Circulube offers three different new units, in two sizes, one supplying cyclical delivery of oil where required. It enables you to incorporate in machine design a foolproof lubrication system, prevents machine damage from inadequate lubrication, and provides maximum flexibility of application.

Write us for Bulletin CL, giving complete, detailed information.

2-gallon Lubricators, Model CLFB continuous delivery, Model CLFC continuous AND cyclic delivery.

½ gallon Lubricator, Model CLWB continuous delivery.

Pressure Signal Switch, Model C-2512.

BIJUR LUBRICATING CORPORATION
Rochelle Park, New Jersey
Pioneers in Automatic Lubrication

2741

Circle 476 on Page 19

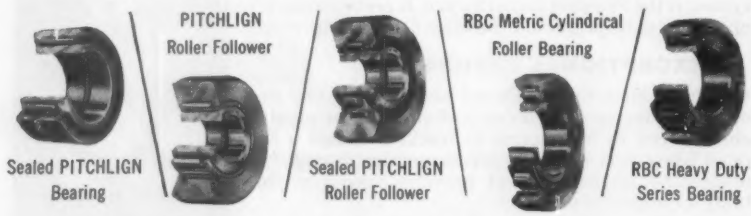
THE ROLLER BEARING WITH SELF CONTROL

Patent Nos. 2765202, 2765203, 2884288

The roller aligning cage of the RBC PITCHLIGN Bearing has its own alignment maintained by the integral flanges of the outer race. This complementary combination assures positive control of the rolling elements and is your guarantee of long life and perfect performance.

THE BUSHING WITH SELF ALIGNMENT

Misalignment caused by manufacturing tolerances, deflections due to heavy loads, long spans between bearing centers or any other cause is immediately washed out by the RBC Heavy Duty Self-aligning Bushing. It saves its price in lower assembly costs.



Be sure to visit us at Booth 117, Sept. 6-16, 1960
Production Engineering Show, Navy Pier, Chicago

ROLLER BEARING COMPANY OF AMERICA
Sullivan Way, West Trenton, New Jersey

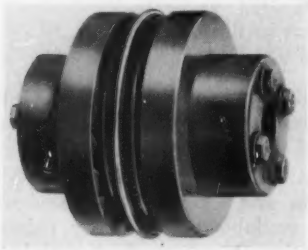
250 rpm, and is suitable for 150 psi air or 2000 psi hydraulic oil pressure. It is available for ¼-in. IPS hose connections. Rotors are threaded ⅝-18 right hand, ⅜-18 NPT right hand male, or ⅜-18 NPT female. **Deublin Co.**, 1919 Stanley St., Northbrook, Ill.

Circle 639 on Page 19

Spacer Couplings

withstand 1 deg angular misalignment

Sure-Flex spacer couplings are equipped with detachable hubs that permit coupling of shafts spread as far apart as 7½ in., depending on coupling size. Spacer couplings can also be removed without disturbing



shaft alignment. Shaft ends fit into the hubs, and each hub is attached to the coupling flange by four cap screws. Coupling is removed from the shafts by unscrewing four cap screws in each hub, allowing central section to be lifted out. Couplings are available on special order to fit particular requirements. They withstand high shock and vibration and all types and combinations of misalignment without wear or internal abuse. Couplings take angular misalignment to 1 deg, parallel misalignment to 1/16 in., free-end float to ⅛ in. **T. B. Wood's Sons Co.**, Chambersburg, Pa.

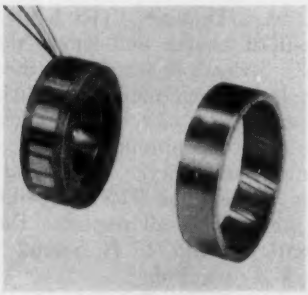
Circle 640 on Page 19

Induction Torque Motor

produces torque of 3.1 oz-in.

Inside-Out induction torque motor features high torque efficiency and small size. Model 103 is 1⅝ in. in diam and ½ in. long. It produces a torque of 3.1 oz-in. when supplied with 10½w per phase of 400 cps, two-phase power. Class-B insulation is used throughout, and wind-

Circle 477 on Page 19



ings are completely encapsulated in epoxy. Design can be adapted readily to many applications where a 12-pole, two-phase pancake motor is indicated. **Curvin Development Co. Inc.**, 13740 Saticoy St., Van Nuys, Calif.

Circle 641 on Page 19

Self-Wicking Lubricant

for extreme operating conditions

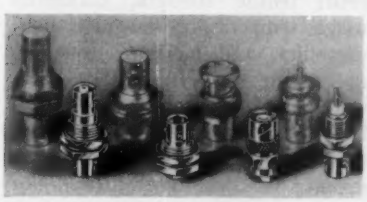
Permawick-280 is recommended for applications involving high or low temperatures, marginal and boundary lubrication, and high thrust loadings for vertical-shaft positions. Key to the special lubricant is a new extreme-pressure additive, formulated specifically for bearing use. In addition to improving operating characteristics of both babbitt and sintered-bronze bearings, lubricant shows greater resistance to degradation and longer life than other wicking lubricants or mineral oils. Formulation has a pour point of −40 F and shows virtually no loss of lubricity and only relatively minor viscosity changes at temperatures to 200 F. **Permawick Co.**, 5319 E. Outer Drive, Detroit 34, Mich.

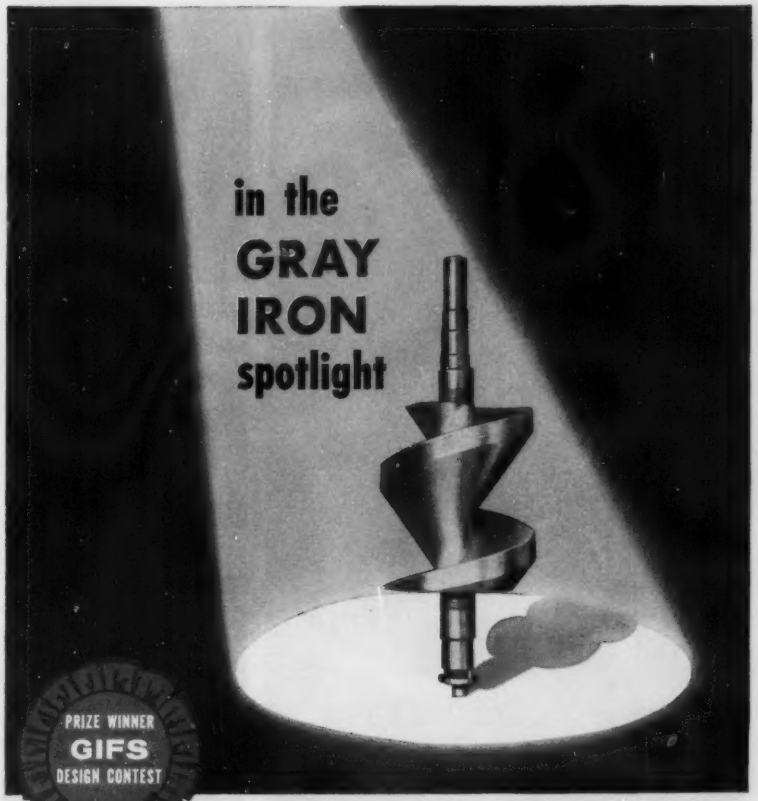
Circle 642 on Page 19

Coaxial-Cable Connectors

are smaller and lighter than size they replace

TPS coaxial-cable connectors are a new UG series miniature designed to replace standard BNC series on





Roots-Connersville Achieves 29% Cost Reduction with Integral Rotor and Shaft

The exceptional design freedom in the gray iron casting process frequently enables the designer to reduce costs by converting multiple piece assemblies into one part. Roots-Connersville recently achieved noteworthy savings by redesigning forged steel shafts onto which were pressed ductile iron rotors into a one piece cast part.

Since the rotor hub formerly had to be large enough to key it to the shaft, the redesign results in 41% greater displacement by permitting smaller hub diameters and correspondingly larger outside diameters in the same housing. Machining was reduced from 27 operations to 15.

Start now to re-evaluate your products in the light of integral gray iron castings. Use the experience and know-how of progressive foundrymen, members of Gray Iron Founders' Society, to help achieve outstanding savings.

FREE DIRECTORY OF PROGRESSIVE FOUNDRYMEN

Lists modern facilities, techniques and types of iron produced by leading gray iron foundries in your area. For a copy write: Dept. G, Gray Iron Founders' Society, Inc., National City-East Sixth Building, Cleveland 14, Ohio.

Specify Modern

GRAY IRON CASTINGS

Made by Informed Foundrymen!

Circle 478 on Page 19

You get greater strength . . . with

SHENANGO CENTRIFUGAL CASTINGS

Downtime, rejects, heavy maintenance costs and too-frequent replacements can be cut down *appreciably* by the use of Shenango extra-strong centrifugal castings.

They provide a finer, *pressure-dense* grain . . . with all the weakening defects eliminated, such as blowholes and sand inclusions.

Though built to stand the most rugged service, each Shenango casting is precisely-dimensioned to your exacting requirements. Whether you need rolls, bearings, bushings, mandrels, sleeves, liners, or any other essentially symmetrical part . . . *specify Shenango* for greater strength, greater wear-resistance, greater lasting power and greater savings, year after year.

Informative bulletins are yours for the asking. Write to: *Centrifugally Cast Products Division,* The Shenango Furnace Company, Dover, Ohio.

SHENANGO CENTRIFUGAL CASTINGS

COPPER, TIN, LEAD, ZINC BRONZES • ALUMINUM AND MANGANESE BRONZES
MONEL METAL • NI-RESIST • MEEHANITE METAL • ALLOY IRONS

Circle 479 on Page 19

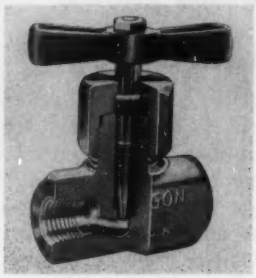
RG 58 C/U cable. TPS is about one-third smaller and lighter than BNC Series. It features a three-pin lock which minimizes rocking of the mated pair and eliminates electrical discontinuity due to vibration and shock. Performance tests indicate the TPS comparable to the BNC in all respects. **Dage Electric Co. Inc.**, 67 N. Second St., Beech Grove, Ind.

Circle 643 on Page 19

Needle Valve

is rated for 10,000 psi

Series 5000 needle valve is a low-cost, general-purpose unit, operation-rated for 10,000 psi. Design prevents valve stem from blowing out or backing out under pressure. Absolute



stem retainment has been achieved by making inside neck threads an integral part of the one-piece, forged carbon-steel valve body. Body is precision machined to ensure absolute alignment of stem to seat. Stem is corrosion-resistant stainless steel, and stem threads are rolled for added strength and turning ease. Teflon back-up ring prevents dirt or contamination from entering valve, and O-ring stem-sealing prevents leakage. **Dragon Engineering Co.**, P. O. Box 185, Norwalk, Calif.

Circle 644 on Page 19

Self-Locking Nut

1000-F unit is rated at 145,000 psi

FN 1014 featherweight locknut exceeds tensile strength, maximum usage temperature, magnetic permeability, and locking torque requirements of NAS 1291C nut standard. It is rated at 145,000 psi axial tensile strength and is for temperatures to 1000 F. Corrosion resistance is rated as excellent. Nut

National Acme's SL2X limit switch

doubly certified

explosion proof

SWITCH SHOWN ACTUAL SIZE

Specify National Acme's SL2X . . . and eliminate limit switching problems under explosive conditions. Tested and certified "explosion-proof" by both Underwriters' Laboratories and the Bureau of Mines, the SL2X is specifically designed for use in the mining, chemical, process industries . . . anywhere explosions cannot be tolerated. Latest of National Acme's dependable SL2 "Machine Life" Limit Switches, the SL2X also offers . . . a variety of cam arrangements for extreme operating flexibility . . . ample overtravel (67°) and by-pass (90°) . . . light operating pressure (12½ lbs. at 1½" radius). Get all the details on this new standard of limit switching dependability and safety. Call, write or wire.

National Acme

THE NATIONAL ACME COMPANY
188 E. 131st STREET
CLEVELAND 8, OHIO

Sales Offices: Newark 2, N. J., Chicago 6, Ill., Detroit 27, Mich.

Circle 480 on Page 19

4th in a series of POWDERED METAL PARTS applications by REESE

when SERVICE
and KNOW-HOW
count as much as
ECONOMY

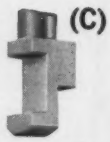
3 Remet Powdered Metal Parts go into Sargent & Greenleaf

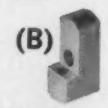
FILE CABINET LOCKS

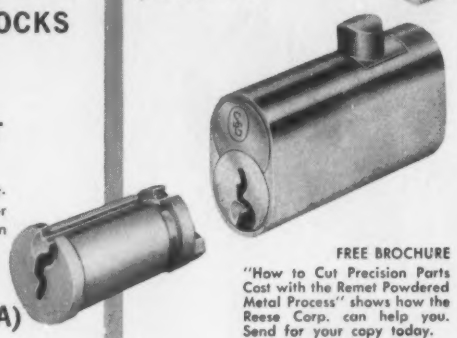
(A) PLUG
(B) FILLER
(C) BOLT

Formerly a zinc base die casting . . . now sintered brass for a higher melting point for use on insulated files.

According to Mr. George Paul, Chief Engineer, Sargent & Greenleaf, Inc., "A number of powdered metal parts producers were contacted to make these low cost, close tolerance, complex parts. Reese was the only one interested. We now find other practical applications and will, of course, use Reese as our prime source".







FREE BROCHURE
"How to Cut Precision Parts Cost with the Remet Powdered Metal Process" shows how the Reese Corp. can help you. Send for your copy today.

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REESE METAL PRODUCTS CORPORATION
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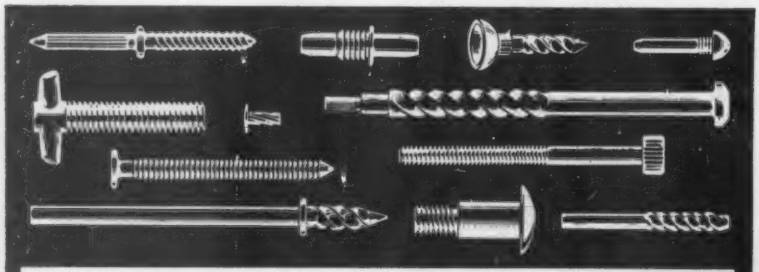
Gears • Pinions • Cams • Ratchets
Oilless Bearings • Bushings • Machine and Structural Parts in
COPPER • BRASS • IRON • ALLOY STEEL • NICKEL SILVER • COPPER INFILTRATED IRON

Circle 481 on Page 19



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Here is a fast, dependable, low cost, quality minded source of supply for JOB-DESIGNED threaded parts and fasteners of all types, in any metal, to fit your own particular assembly problem. Recognize the fact that a fastener designed specifically to fill a seemingly complex assembly requirement can easily cost less than design modification to accommodate so-called standard rivets. Assembly costs are a very major part of manufacturing expense. Most of this is labor. The fastening medium itself is usually a minimum item. If a Job-Designed fastener makes assembly simpler and faster, permits the use of fewer fasteners, allows the designer functional freedom and improves product efficiency, yours is a specifying job well done. All these possibilities are available when you come to Hassall for design assistance and quotation on challenging, difficult or unusual rivets, threaded nails, drive screws and other cold headed parts. Short or long runs, pilot quantities, engineering counsel, over 100 years of intimate association with cold heading—and a deep appreciation and regard for the concept of value analysis—all are a part of the Hassall service to you.

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JOHN HASSALL, INC.
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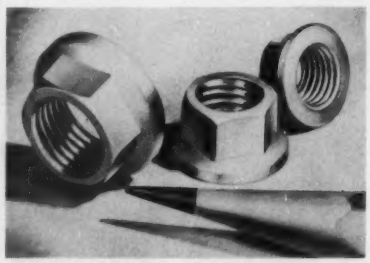
Circle 482 on Page 19



has low magnetic permeability and reduced-height hexagonal wrenching area designed for minimum mass. It is made of A-286 heat and corrosion-resistant alloy, silver plated to AMS 2410 standards. Integral self-locking feature provides three-point positive lock. Nut is available in standard Class 3B sizes from No. 4-40 through ⅜-24. **Standard Pressed Steel Co.**, Jenkintown, Pa.

Circle 645 on Page 19

Pressure-Sensitive Adhesive

for polyethylene, polystyrene, and other materials

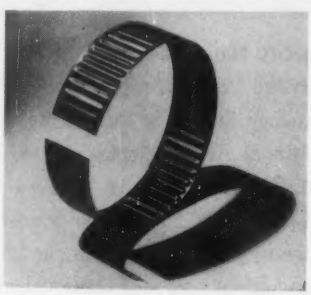
Rubbastix is a noninflammable, water-based adhesive for bonding polyethylene, polystyrene, vinyl, wood, foamed plastics, paper, fabric, and other materials. It is applied by brush, roller coater, or spray, and dries with a permanent, aggressive tack. Adhesive dries transparent, is nonstaining, and requires only one-side application, either wet or dry. It becomes water resistant when dry. **Rubba Inc.**, 1015 E. 173rd St., New York, N. Y.

Circle 646 on Page 19

Tolerance Ring

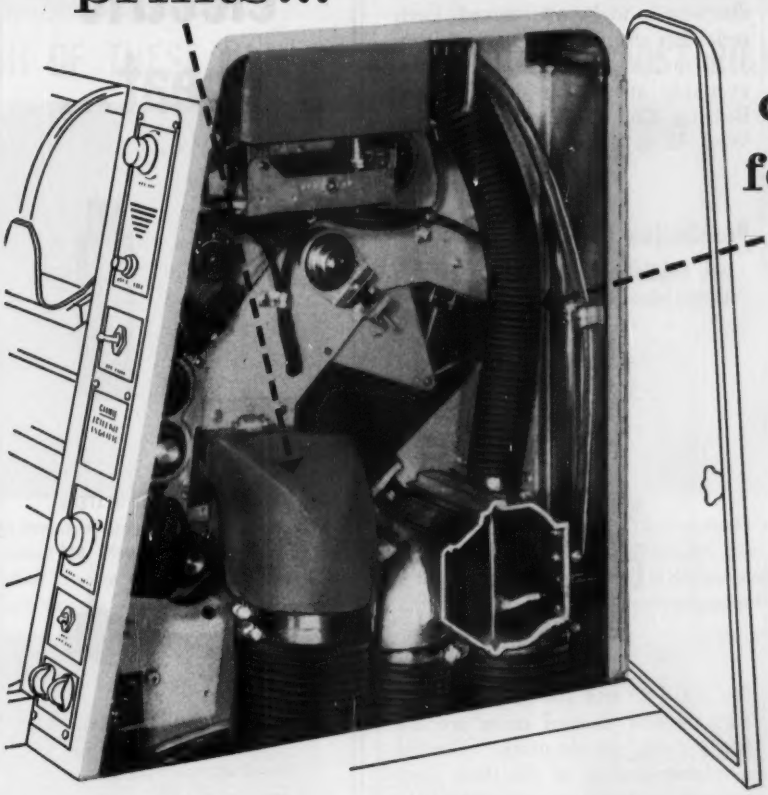
allows wide tolerances, provides for self-aligning

Star Tolerance Ring is a corrugated open ring of hardened steel. It serves as a wedging shim between a shaft and its mating part or a



In the Lancer Whiteprinter, Flexible Tubing

1...provides suction to separate originals from prints...



2... conveys air for cooling...

3... exhausts heat and fumes

Proof that Flexible Tubing can solve a wide range of design problems

Copymation, Inc., designers of the LANCER Dry Process Whiteprinter, had to solve three tough air handling problems: how to provide suction... how to convey air for cooling... how to exhaust heat and fumes — all in a very limited space!

Solution to all three problems: a rugged nonmetallic duct with a wire helix — Flexible Tubing's "Flexflyte." Flexflyte is air tight and non-collapsing — provides strong, continuous suction for separating originals from prints. Flexflyte is lightweight and highly flexible — easily conveys air through cramped areas. Flexflyte is flameproof and corrosion-resistant — safely exhausts heat and fumes. Perfect example of the design problems solved with Flexible Tubing!

If you work on any kind of original equipment involving the handling of air, liquids or light solids, there's a Flexible Tubing product that can do the job! It's at work today in electronic computers, vacuum cleaners, farm combines and hundreds of other places. Consult your factory-trained Flexible Tubing regional sales engineer. He'll be glad to give you technical assistance.

Flexible Tubing
CORPORATION
Anaheim (Los Angeles) • Guilford, Connecticut
Hillside (Chicago)

FLEXIBLE TUBING CORPORATION
69 New Whitfield St., Guilford, Conn.

Gentlemen:
I'm designing a new product ☐. I'm redesigning an old one ☐; One of my problems is the handling of air ☐ liquids ☐ light solids ☐. Could be Flexible Tubing can help me solve them. I'll give you 10 minutes to show me, to prove it. Phone for appointment ☐. No problems right now. Send me literature for my files ☐.

NAME_____

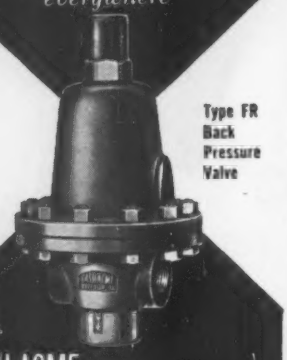
COMPANY_____

ADDRESS_____

CITY_____ STATE_____

Circle 483 on Page 19

CASH-ACME . . . meeting pressure control needs for product design engineers everywhere



Type FR Back Pressure Valve

CASH-ACME SPECIAL BY PASS VALVE HELPS AIR FORCE LICK ICE PROBLEM IN ARCTIC

The greatest potential "saboteur" at Strategic Air Force Command bases in the Arctic is ICE. That's why mobile de-icers are as highly prized as radar.

In perfecting modern de-icing equipment, air force designers received an invaluable assist from Cash-Acme engineers. Since ordinary valves and liquids are completely inoperative at 65° below zero, new methods were urgently needed. With the help of Cash-Acme Back Pressure Valve (Type FR) specially modified for this extremely rigorous job—a unique sprayer was developed for discharging ethylene glycol.

Using high pressure spray nozzles to thaw out iced-up areas, crewmen keep jet bombers and interceptors ready for instant take-off.

TYPE FR BACK PRESSURE VALVE

Ready for tough, exacting jobs anywhere. Automatically controls desired maximum pressure by maintaining a determined inlet pressure at valve and relieving into a low pressure line. Readily usable for all liquids and gases. Slight modifications make it useful as a differential pressure regulator. For Answers to Pressure Control Problems in Your Product.

A. W. CASH VALVE MFG. CORP.

6627 East Wabash Ave., Decatur, Ill.

CASH ACME

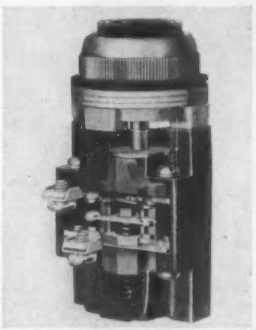
Circle 484 on Page 19

housing and its related part. It requires only wide tolerances, due to its elasticity. Unit provides for self-aligning, absorbs shock, and is easily assembled and disassembled. It eliminates the effect of variations of temperature, keys, and keyways. Series AN is for "basic shaft" applications where shaft diameter is to be maintained, and Series BN is for "basic hole" use where bore diameter is to be maintained. Each series has size range at present from 3/16 to 2 in., with sizes to 10 in. available at a later date. **Roller Bearing Co. of America**, Sullivan Way, West Trenton, N. J.

Circle 647 on Page 19

Pushbutton Control Units

are available in three new lines



No. 100-HO and 100-H pushbutton stations and control units are for heavy-duty applications. Devices available in each of the three lines include pushbutton units, selector-switch units, standard pilot lights, and push-to-test pilot lights or lighted pushbuttons. Many parts are interchangeable among the three lines. Availability of seven colors for both buttons and ferrules permits double color-coding arrangements. Stationary terminals are held solidly to the contact blocks with individual screws. Silver, wipe-action contacts permit reliable contact in all atmospheres. **Clark Controller Co.**, 1146 E. 152nd St., Cleveland 10, Ohio.

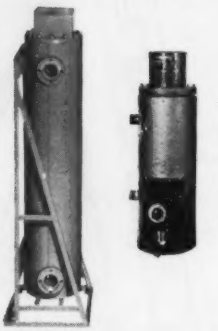
Circle 648 on Page 19

Plastic Film

for nameplates and emblems

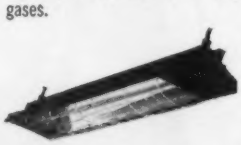
Scotchcal tough plastic film for nameplates and emblems which can

VULCAN meets your needs for electric heat...



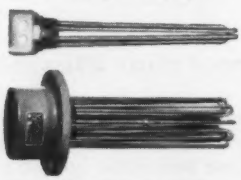
VULCAN CIRCULATION HEATERS

Complete range of sizes for heating oil, water, steam, air and gases.



VULCAN RADIANT HEATERS

Unlimited applications for spot comfort heating and drying.



VULCAN IMMERSION HEATERS

For direct immersion in all types of liquid materials.

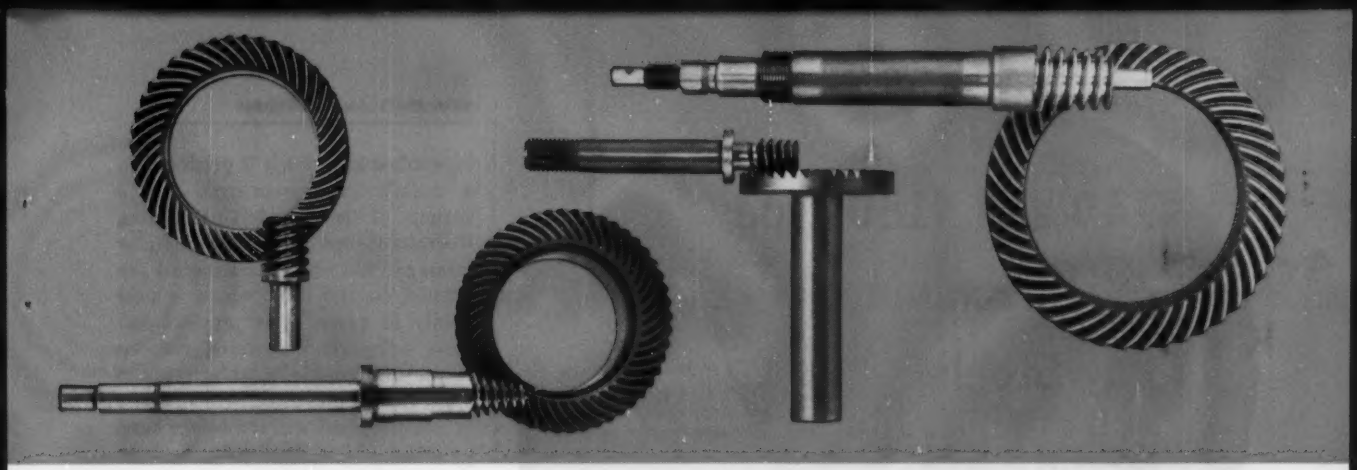
Vulcan's complete line includes strip, cartridge, tubular, band and other heaters. Write for catalog VG-200.

VULCAN

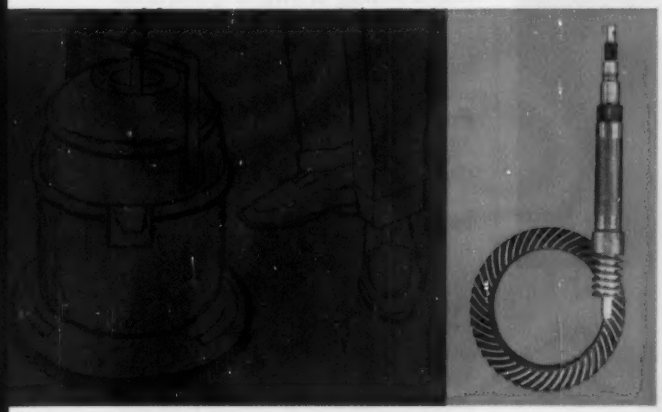
Versatility in Electric Heating

VULCAN ELECTRIC COMPANY, Danvers, Mass.

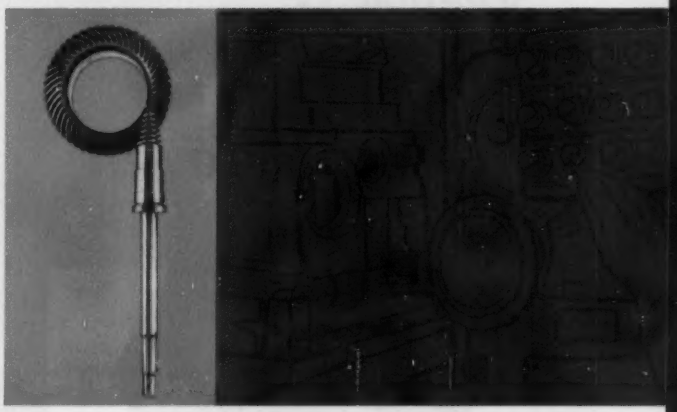
Circle 485 on Page 19



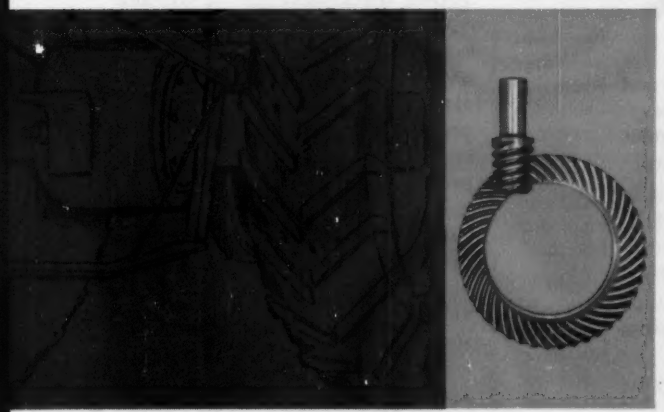
WHICH OF THESE HIGH-RATIO HYPOIDS IS "**JUST RIGHT**" FOR YOUR PRODUCT?



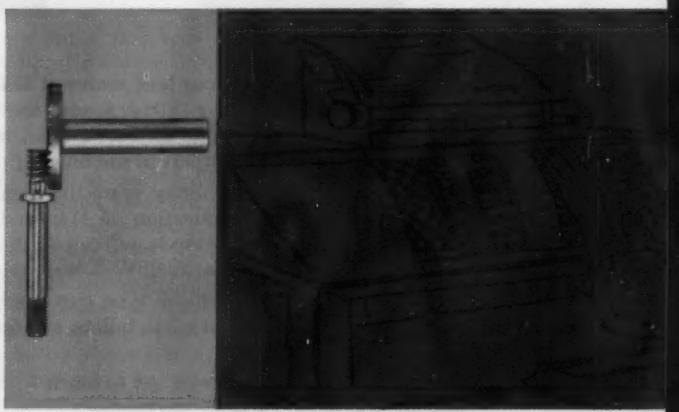
For hand tools. Where space is a problem—as in portable tools like this one—the high offset lets you design a more compact unit. Choose just the offset to solve your design problem with a more flexible, more compact unit than the corresponding worm and wheel.



. . . or machine tools. This high-offset pair lets you combine high reduction with strength, compactness and other advantages you might find profitable in designing machine tools. High-ratio hypoids can be produced on Gleason equipment for ratios of 1:10, 1:40 or even higher.



Big and strong. Where you need strength—as in farm machinery—high-offset hypoid pinions (with teeth which tend to "wrap around") are larger and stronger than corresponding bevel pinions. An extended shank on cylindrical pinions makes very rigid straddle mountings practical.



. . . or small and smooth. For smooth operation—as in office equipment that must run quietly—high-offset pairs provide smooth, quiet tooth action. Because teeth "wrap around" the pinion, you get continuous action—even with just one or two teeth! Grinders are available for applications requiring precision finish.

High-offset or high-ratio hypoids can be cut, tested, and quenched on the same Gleason equipment that is used on more familiar spiral bevel and hypoid gears. You can get more information about Gleason high-ratio hypoid gears by writing for free literature. Submit your prints for recommendations.

GLEASON WORKS

1000 UNIVERSITY AVE., ROCHESTER 3, N.Y.

Circle 486 on Page 19

4140 and 4150 type Free-Machining Alloy Steels machine better than regular types . . . and cost less in the finished part!

Wheelock, Lovejoy is your best source of 4140 and 4150 type free-machining alloy steels, the easy-working steels that machine far better than regular type steels, and which cost *less* in the finished part.

Wheelock, Lovejoy, for many years the pioneer in the development and application of 4140 and 4150 type free-machining alloy steels, offers you the most extensive stocks anywhere, in all W-L warehouses.

Available variety of 4140/50 type free-machining stock includes round, square, flat, billets, and forgings to specifications.

For best stocks, best service, get in touch with your nearest Wheelock, Lovejoy warehouse.

W-L STEEL SERVICE CENTERS – Cambridge • Cleveland Chicago • Hillside, N. J. • Detroit • Buffalo • Cincinnati

AGENTS – Southern Engineering Company, Charlotte, N.C.; Sanderson-Newbould, Ltd., Montreal and Toronto

"The Alloy Steel Center"

WHEELOCK, LOVEJOY & COMPANY, INC.

134 Sidney Street, Cambridge 39, Mass.

STEEL SERVICE CENTER INSTITUTE

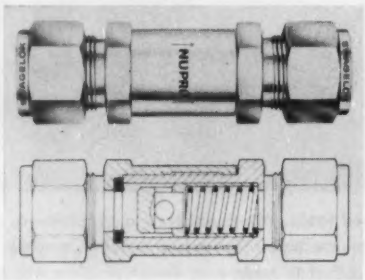
Circle 487 on Page 19

be applied at a touch is produced in a metallic chrome or gold and a variety of basic colors, including fluorescent orange. Any design or message can be silk-screened or printed on the film, which is held firmly in place by a pressure-sensitive adhesive. Premasked versions of the film enable manufacturers to apply nameplates directly to any base or prime-coated surface before final painting. After final painting over the entire unit, masking is removed and nameplate is edge-sealed. **Minnesota Mining & Mfg. Co.**, 900 Bush Ave., St. Paul 6, Minn.

Circle 649 on Page 19

Poppet Check Valve

has turbulence rings to provide stability



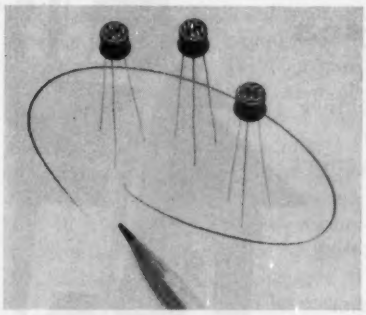
Poppet check valve for 3/8, 1/2, and 5/8-in. tubing is for use in instrument, process, and control lines to obtain unidirectional flow. It can also be used in fluid-service lines to prevent system contamination and equipment damage. Poppet design provides large flow areas for minimum pressure drop. Turbulence rings are incorporated to provide dynamic stability and rapid shut-off. One Buna-N rubber ring forms valve seat to assure bubbletight sealing at low back pressure, and also forms the body seal. Valve is available in 316 stainless steel and brass. **Nuclear Products Co.**, 15635 Saranac Rd., Cleveland 10, Ohio.

Circle 650 on Page 19

Silicon Transistors

are unijunction type with fixed-bed construction

Three silicon unijunction transistors are designed for solid-state relay, triggering, and switching circuits in industrial electronic equipment.



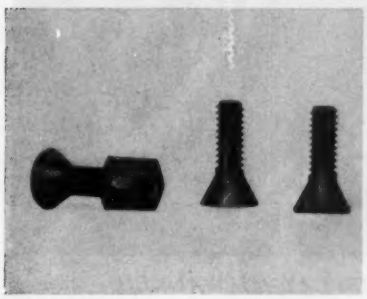
Type 2N1671 is for general-purpose industrial use where circuit economy is of primary importance. Type 2N1671A is specified for use in firing circuits for silicon-controlled rectifiers and other applications where a guaranteed minimum pulse amplitude is required. Type 2N1671B is intended for use where a low emitter-leakage current and a low trigger current are required. All of the units have a maximum intrinsic standoff ratio of 0.62. Interbase resistance characteristics are a minimum of 4.7 and a maximum of 9.1 kilohms at 25 C. Minimum valley point current of all the transistors is 8 ma. Maximum rms power dissipation rating for the devices is 450 mw in an ambient temperature of 25 C. All utilize fixed-bed construction for maximum mechanical reliability. Transistors are hermetically sealed, having an all-welded case, with leads electrically isolated from the case. **Semiconductor Products Dept., General Electric Co.**, Charles Bldg., Liverpool, N. Y.

Circle 651 on Page 19

Screws and Nuts

are molded and machined of glass fiber

Molded and machined 1/4-20 screws and nuts, made completely of glass fiber, are designed for use in missiles, rockets, and other applications



as easy as

falling off a log

It's entirely possible that sensitive relays frustrate you, perhaps almost as much as they do us. Even the world's finest (applicable Sigma types on request) occasionally demonstrate Flagle's Law of the Perversity of Inanimate Objects, by performing in a totally unexpected manner for reasons that are either obscure or completely mysterious.

Frequently we have found that such problems can be anticipated and thereby overcome by a ridiculously simple dodge. Consider the relay as three devices: (a) a motor, (b) a switch, and (c) something that may have to work extra fast, extra certainly or extra something else amid the 100 g's, heat, dust, blood, sweat and 100 hours of salt spray tears present in both birds and barroom juke boxes.

With the problem thus neatly parceled out, you then consider whether you have an on-off, sliding current or single pulse signal for the "motor" to respond to; a resistive, inductive, horsepower or dry circuit load to hang across the switch, and for how long and how often this load will want to be turned on or off; and what sort of surroundings the relay will *actually* have, and whether all the taxpayers or just one 25¢ customer will suffer if the relay doesn't operate. There are other considerations such as size and cost, which you'll have to face eventually, but it's usually best to get a, b and c straightened out first.

If it turns out that the motor, switch and environmental immunities you have to have just don't exist in a single relay, either you'll have to change something or use more than one relay — or talk somebody into building you a special relay. You can do one other thing: call up one of Sigma's application engineers and tell him your troubles.

He has all sorts of answers, is anxious to have you buy some relays (Sigma) that will work for *you*, and has the advantage of doing nothing but wrestling with application problems all day long. You'll have to answer a lot of questions, but that's part of the game. We can also send you technical dope sheets on various application considerations, if you'll tell us what you particularly want to know. It's surprising how well even a relay will behave, once it's applied with your eyes open. This is one important aspect of reliability that may be lost in the statistical jungle.

SIGMA

SIGMA INSTRUMENTS, INC.
89 Pearl Street, So. Braintree 85, Mass.

AN AFFILIATE OF THE FISHER-PIERCE CO. (Since 1938)

Webster hydraulics "take command" at sea

Deep water fishing craft or harbor-bound tugs now have faster, more positive control — with Webster hydraulics. On a newly developed marine gear, an exclusive metering-type control valve actuates forward and reverse clutches *hydraulically.* A Webster HC gear-type pump supplies a ready source of fluid power — a fingertip touch puts it in action. Smoothly, *quickly!* Just what the skipper needs for tricky maneuvering, split-second decisions.

Ashore, HC hydraulic pumps find wide and versatile use in pressure lubricating, oil circulating and lift systems . . . on industrial, agricultural and construction equipment. In fact, where exceptional dependability, compact design and ease of adaption are your prime requirements, chances are the Webster HC series will match both your product and the job.

Hydraulics on your product? Would an economical Webster pump, valve or motor improve performance? A specially-trained Webster hydraulics engineer can show you without obligation. Write!

OIL HYDRAULICS DIVISION

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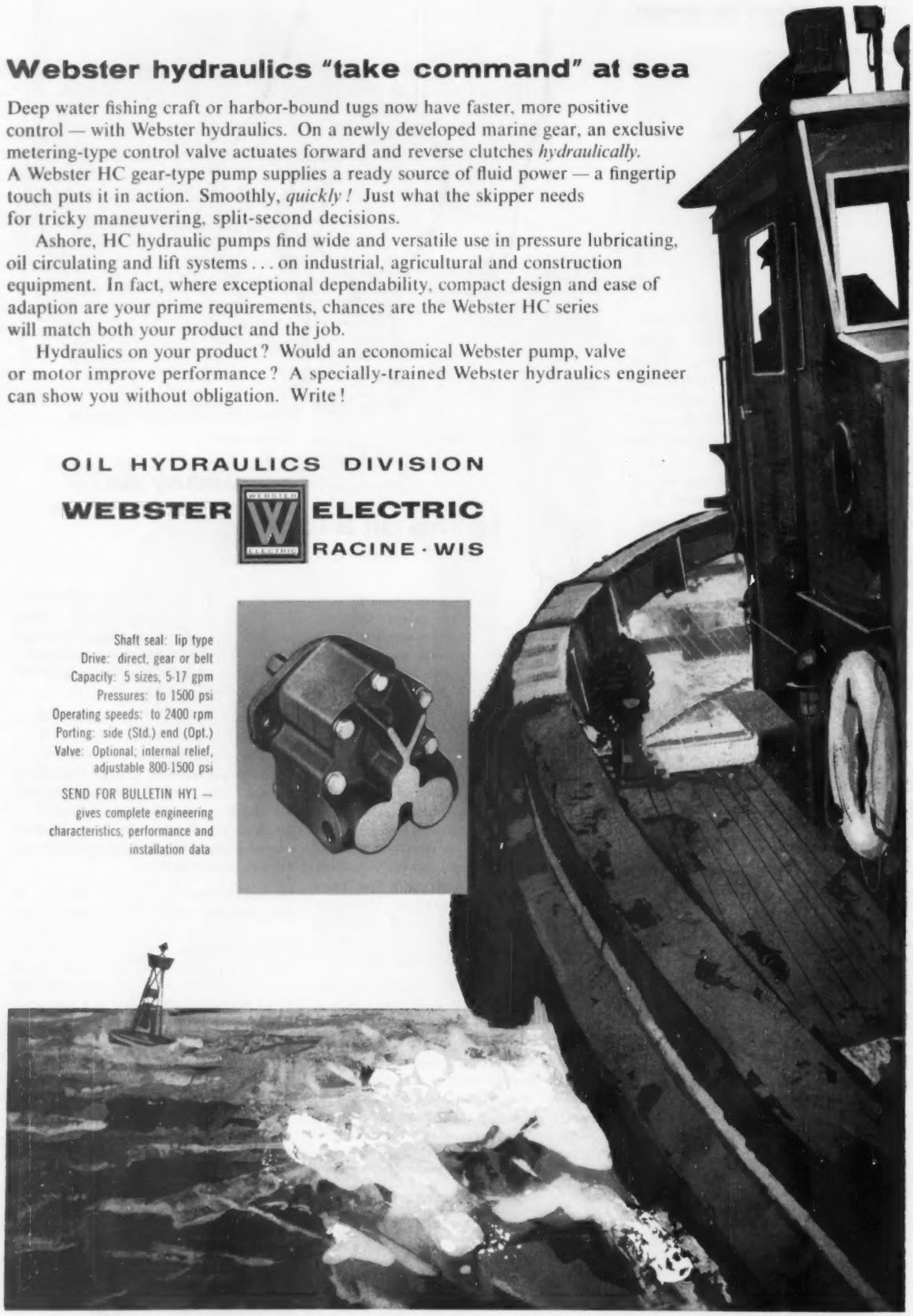
RACINE · WIS

Shaft seal: lip type
Drive: direct, gear or belt
Capacity: 5 sizes, 5-17 gpm
Pressures: to 1500 psi
Operating speeds: to 2400 rpm
Porting: side (Std.) end (Opt.)
Valve: Optional; internal relief, adjustable 800-1500 psi

SEND FOR BULLETIN HY1 — gives complete engineering characteristics, performance and installation data



PLEASE STOP IN — BOOTH 400 — SAE ENGINEERING DISPLAY, MILWAUKEE.

where exceptional heat and wear resistance is a principal requirement. Material is Trevarno F-120, a glass fabric preimpregnated with phenolic resin. Material is a modified phenolic resin. Material is a modified phenolic resin for use where high-temperature strengths are required, and it is designed for low-pressure molding and high-pressure laminating. Glass fiber is used because of low heat conductivity and because it vaporizes at a steady rate when exposed to extreme temperatures, tending to cool itself. **Pam-Pro Plastics,** Menlo Park, Calif.

Circle 652 on Page 19

Steel Bolts

are plastic capped

Steel bolts, available in any size or shape, now have Kralastic MM plastic caps to resist impact, weather, and acids. Colored plastic can be used when desired to enhance the appearance of the bolts. In most instances, plastic applied on the inside of the bolt head can be used in place of a washer. Plastic resists cold flow under loads. **Clear-Cite Products,** 1323-1325 Webster Ave., Chicago 14, Ill.

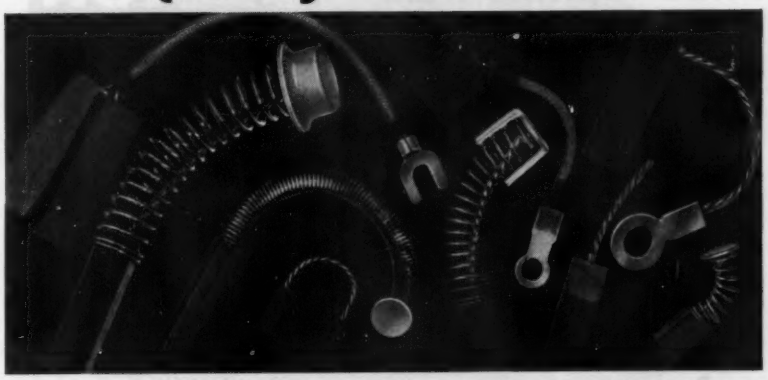
Circle 653 on Page 19

Hydraulic Valves

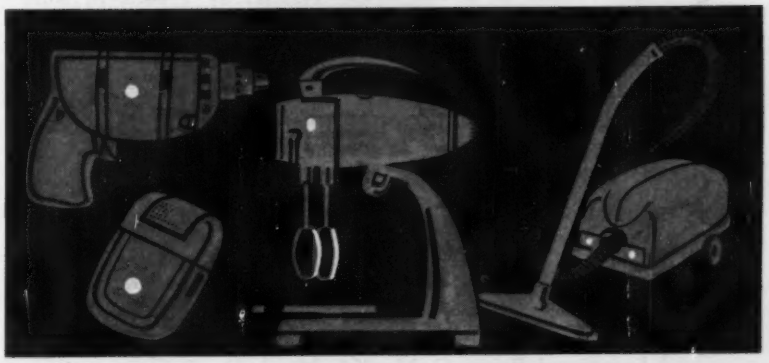
have improved back-pressure characteristics

Velvet-Touch parallel-circuit, directional-control hydraulic valves have 50 cent improved back-pressure characteristics and increased system efficiency over previous line. Model A, series 20, and Model A, series 35, have nominal ratings of 20 and 35 gpm and 2000 psi systems pressures. Exponential curved edges on spool lands provide a high degree of flow metering. Also built into all valve models is an extremely low-

Quality BRUSHES



for any FRACTIONAL H.P. MOTOR



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for leading Motor Manufacturers for OVER 50 YEARS

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2 CALCULATING CRITICAL SPEEDS by Helmut G. Hoeschel, February 4, 1960 (6 pages)

3 Linearity Problems in COMPRESSION SPRINGS by Frank A. Votta Jr., April 4, 1957 (2 pages)

4 Key Factors in SET-SCREW Selection by Francis R. Kull, April 30, 1959 (6 pages)

5 CHOOSING THE RIGHT COLOR by Faber Birren, August 6, 1959 (7 pages)

6 HEAT-TREATED POWDER-IRON PARTS for improved strength and hardness by Navin Kothari, October 30, 1958 (4 pages)

7 How To Select The Right STAINLESS STEEL by Richard E. Paret, June 11, 1959 (10 pages)

8 SIMPLIFIED COLUMN DESIGN by Helmut G. Hoeschel, April 2, 1959 (6 pages)

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10 ENGINEERING WRITING to Eliminate Gobbledygook by Gibson A. Cederborg, March 7, 1957 (4 pages)

11 Charts and equations for a simplified approach to HELICAL SPRING DESIGN by J. Hirschhorn, February 19, 1959 (5 pages)

12 WHY ENGINEERS WORK by Eugene Raudsepp, February 4, 1960 (12 pages)

13 ELECTRIC MOTOR SELECTOR by MACHINE DESIGN's Staff, July 24, 1958 (10 pages)

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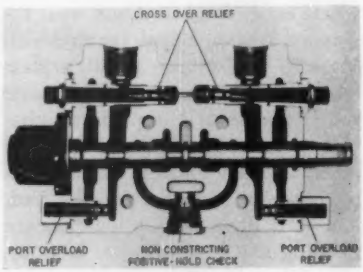


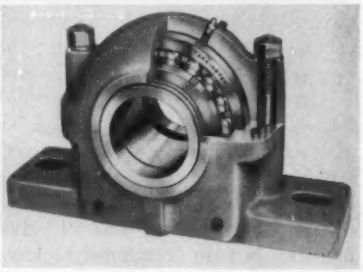
back pressure feature. In addition to the primary function as a directional-control valve, units can also be used as crossover relief valves, overload port relief valves, pilot-operated port checks, anti-cavitation checks, and flow restrictor checks, all of which can be built into the working section, depending upon system requirements. **Commercial Shearing & Stamping Co.**, 1775 Logan Ave., Youngstown, Ohio.

Circle 654 on Page 19

Pillow Blocks

have self-aligning spherical roller bearings

Heavy-duty pillow blocks, with self-aligning spherical roller bearings in split housings, are available in 143 sizes in two series. Series SAF has two bolts clamping cap to base, and Series SDAF has heavier castings and four cap bolts. All sizes are available with straight-bore bearings for shouldered shaft mounting, or with adapter bearings suitable for mounting on straight commercial shafting. Housing seats are machined to bearing widths plus $\frac{3}{8}$ in., permitting each pillow block to be used as a floating unit or, with standard $\frac{3}{8}$-in. stabilizing ring in place, as a fixed pillow block. Spherical roller bearings used in the pillow blocks have high radial and thrust load capacities combined with low torque. Integral guide flange, adding strength to the bearing inner



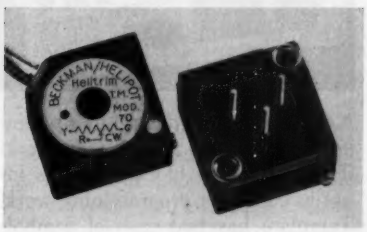
ring, guides rollers and prevents roller skew. Open-end retainer pockets allow lubricant to reach all contact surfaces. **Bantam Bearings Div., Torrington Co.**, South Bend 21, Ind.

Circle 655 on Page 19

Trimming Potentiometers

square units have all-metal housings

Helitrim ½-in. square trimming potentiometers are Model 70, with leads, and Model 71, equipped with pins. Features include high-temperature, all-metal housings, humidity resistance, and tough Teflon leads or gold-plated terminals. Both



models have 10 to 50,000 ohm resistance range, 1 w power rating at 50 C, and a maximum temperature of 150 C. Slip-clutch stop positively prevents the wiper from going off the coil end. **Helipot Div., Beckman Instruments Inc.**, 2500 Fullerton Rd., Fullerton, Calif.

Circle 656 on Page 19

Alloy-Steel Bar

eliminates heat-treating of parts

ETD 150 alloy-steel bar takes the place of quenched and tempered bar steels and eliminates heat treating and costly secondary operations. It is high in strength, with a guaranteed minimum 150,000 psi tensile strength and minimum hardness of Rockwell C 32, yet machines readily compared to other alloy steels of similar hardness. ETD 150 is a 4100 series 0.40 per cent minimum carbon alloy-steel bar. Available in rounds 7/16 through 3½ in., bars are recommended for shafts, gears, pinions, fasteners, axles, and other parts to replace heat-treated alloy steels. **La Salle Steel Co.**, P. O. Box 6800-A, Chicago 80, Ill.

Circle 657 on Page 19

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The manufacture of small precision metal parts—in large volume—can sometimes take on the aspects of a bad dream. The problems are frequently numerous and complex. Their solution calls for specialized experience.

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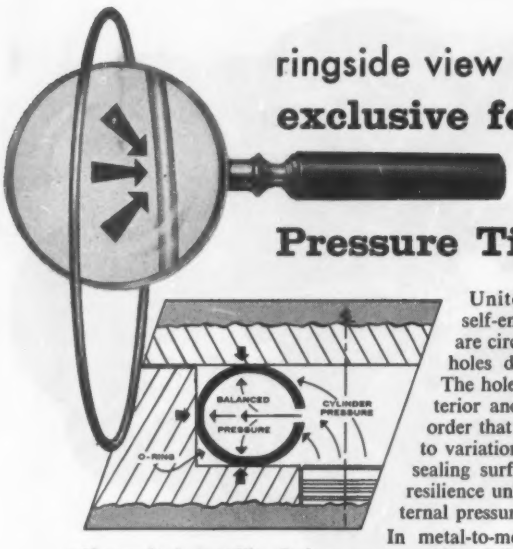
progress through precision **SPECIAL METAL PARTS**

THE TORRINGTON COMPANY Torrington, Connecticut

Circle 493 on Page 19



ringside view of United's **exclusive feature** for

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United's exclusive, patented* self-energized metallic O-rings are circular tubes vented by tiny holes drilled in the ring wall. The holes are to balance the interior and exterior pressures in order that the ring may respond to variation in deflection of the sealing surfaces with a natural resilience uninhibited by the external pressure.

In metal-to-metal applications, self-energized metallic O-rings are capable of forming positive, permanent, non-corrosive static seals under extreme temperatures from —321°F. to 1800°F., and under pressures equal to ultimate compression stress of the metal itself. Available in various metals and finishes, ⅜" dia. to any size or configuration. United also makes non-vented and pressure-filled O-rings; and wire and brazing O-rings. Write for free 22-page booklet (on your letterhead please).

PATENTS 2,809,269; *2,837,360

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Circle 494 on Page 19

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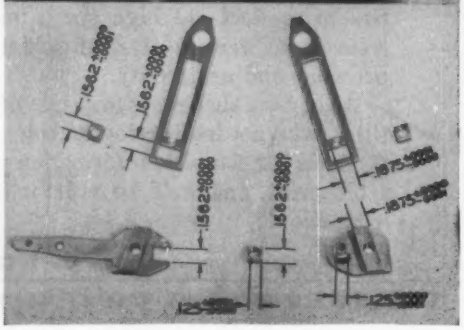


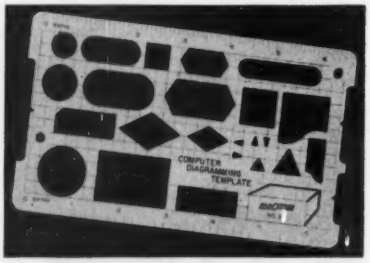
Circle 495 on Page 19

ENGINEERING DEPARTMENT

EQUIPMENT

Computer Template

for computer programming work



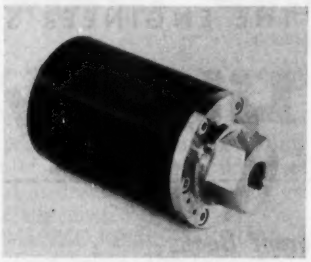
No. 54 computer diagramming template is designed for drawing workflow charts and block diagrams for use in computer programming work. Template has two sizes of symbols for decisions, switches, operations, modifications, drum storage, desk file, consoles, and exceptions. Measured off in 0.25-in. grid, it has one scale in 10ths and one scale for standard line spacing, 6 lines per in. Made of 0.030-in. matte-finish plastic, template is 7 x 4 in. All cut-outs are precision smooth. **Rapidesign Inc.**, P. O. Box 429, Burbank, Calif.

Circle 658 on Page 19

Pressure Transducer

in ranges from 0.5 to 1000 psi

DC output pressure transducer, operable from 115-v ac line, combines in a single housing a variable-reluctance transducer and a carrier-demodulator for dynamic and steady-state pressure measurement. Model CP51 can be furnished with output of 0-5 v dc for voltage-controlled systems or 0-1 ma for galvanometer recording. It accepts corrosive liquids and gases both sides, and is available in ranges of 0.5 to 1000 psi, differential, gage, or absolute. In differential service, line pressure rating is 2000 psig. Shock or static acceleration of 100 g, any axis, and vibration of 35 g, 50-2000 cps, will



not affect calibration. **Pace Engineering Co.**, 13035 Saticoy St., North Hollywood, Calif.

Circle 659 on Page 19

Polyester Film

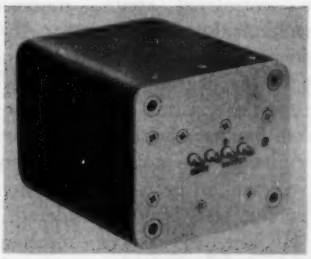
produces erasable ink-black lines

Polyester wash-off film, called Dupro, produces erasable ink-black lines from pencil originals, and permits ink or pencil-drawn additions. Reproduction can then be used to produce sharp reprints at high machine speeds. Film has high transparency for reproduction and long shelf-life expectancy without loss of wash-off characteristics. It is exceptionally durable and water resistant. **Keuffel & Esser Co.**, Third & Adams Streets, Hoboken, N. J.

Circle 660 on Page 19

DC Power Supplies

range in output from 6.3 to 36 v



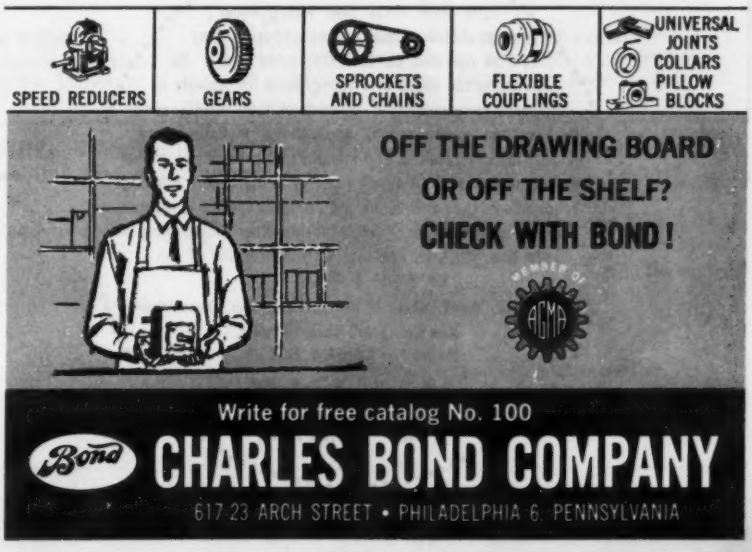
Seven completely transistorized dc power supplies are component-type units, completely contained in a military-type can. They range in output from 6.3 to 36 v. Units have a maximum output rating of 30 w with voltage regulated to ±0.05 per cent against line and load variations. Insensitive to input frequency variations, supplies operate on 50, 60, or 400 cps. **Sorenson & Co.**, South Norwalk, Conn.

Circle 661 on Page 19

DESIGNED FOR THE DESIGNER

Bond Stock Power Transmission Equipment is routinely selected as integral components for new machine designs. Design experts find it saves time and money to check with Bond first before creating special equipment to solve a design problem. Frequently it develops that a Bond Stock Component answers the purpose without resorting to a new engineering approach, expensive dies and costly delay.

Should your situation demand innovation, Bond will be happy to manufacture transmission equipment to your specifications. Bond's almost three-quarters of a century in power transmission design provides a world of special experience at your service.



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THE ENGINEER'S Library

Recent Books

Lubrication of Bearings. *By E. I. Radzimovsky, associate professor of mechanical engineering, University of Illinois; 338 pages, 6¼ by 9¼ in., clothbound; published by The Ronald Press Co., 15 East 26th St., New York 10, N. Y.; available from* MACHINE DESIGN, *$10.00 per copy postpaid.*

Emphasis is placed on hydrodynamic theory and its application to bearing design. Importance and influence of assumptions in all derivations based on the theory are considered.

Assumptions emphasize the limits within which the results of the derivations are true and applicable. Application of theory to basic design problems is illustrated by examples that help to develop the material.

Progress in Non-destructive Testing—Volume 2. *Edited by E. G. Stanford and J. H. Fearon; 250 pages, 6½ by 10 in., clothbound; published by The Macmillan Co., 60 Fifth Ave., New York 11, N. Y.; available from* MACHINE DESIGN, *$12.00 per copy postpaid.*

Major emphasis is placed on devising nondestructive tests which can be correlated with destructive mechanical-properties tests. If this can be accomplished, it is concluded that the degree of uniformity of properties existing throughout complete batches of material can be determined. The notion that destructive tests can be replaced by nondestructive tests is not considered.

High-energy x-rays, mechanical testing of high polymers, application of electrical methods, ultrasonic waves, and radioactive isotopes are discussed.

New Standards

MVBD & MPTA Standard No. 301-1960—Welded Steel Conveyor Pulleys: Recommended Load Ratings for Standard Pulleys. *15 pages, 8½ by 11 in., paperbound; available from Multiple V-Belt Drive & Mechanical Power Transmission*

Sixth Conference on Mechanisms

cosponsored by Purdue University and Machine Design

OCTOBER 10-11, 1960 • Lafayette, Indiana • PURDUE UNIVERSITY

PURPOSE of this continuing series of Conferences is to promote better understanding, design and application of mechanisms. All designers and engineers interested in the design and development of mechanisms are cordially invited.

ADVANCE REGISTRATION may be completed with the form below. The fee of $40.00 includes a banquet on October 10 and a luncheon on October 11, as well as a copy of the *Conference Transactions*.

HOUSING RESERVATIONS may be made with the Union Club on the Purdue campus by the form below. Rooms are also available at the Fowler Hotel in Lafayette (write direct), or those driving may prefer Morris-Bryant Motel, Cedar Crest Motel, Esquire Motel, or Green Acres Motor Court (all 2-4 miles north on U. S. 52).

MONDAY, OCTOBER 10

9:30 a.m.
SESSION 1—Fowler Hall—Memorial Center

FOUR CORNERSTONES OF KINEMATIC DESIGN
Thomas P. Goodman, kinematics engineer, General Engineering Lab., General Electric Co., Schenectady, N. Y.

MECHANICS IS NOT A CLOSED BOOK
C. W. Musser, research advisor, United Shoe Machinery Corp., Boston, Mass.

1:30 p.m.
SESSION 2A
Room 214
Memorial Center

Session 2A

AN APPLICATION OF POLYDYNE CAM DESIGN
S. A. Okcuoglu, advisory engineer, Engineering Laboratory, International Business Machines, Lexington, Ky.

FILTER THEORY APPLIED TO CAM DYNAMICS
Theodore Weber Jr., consulting engineer, Nyack, N. Y., and chief engineer, Cam Engineering Div., Howard Holmes Inc., White Plains, N. Y.

DESIGNING CAMS FOR ANALOG COMPUTERS
Charles Eumurian, principal engineer, Mechanical Div., General Mills Inc., Minneapolis, Minn.

1:30 p.m.
SESSION 2B
Fowler Hall
Memorial Center

Session 2B

SERIES DESIGN OF FOUR-BAR MECHANISMS
Edward E. Hahn, Purdue University, Lafayette, Ind.

LINKAGES WITH ROTATING INPUT AND LARGE OSCILLATING OUTPUT
Raphael Aronson, Purdue University, Lafayette, Ind.

SYNTHESIS OF FOUR-BAR FUNCTION GENERATORS
J. P. Vidosic, professor of mechanical engineering, and H. L. Johnson, research engineer, Georgia Institute of Technology, Atlanta, Ga.

FOUR-BAR STRAIGHT-LINE MECHANISMS
Delbert Tesar, Department of Applied Mechanics, Kansas State University, Manhattan, Kans., and James C. Wolford, Department of Engineering Mechanics, University of Nebraska, Lincoln, Nebr.

6:30 p.m.
BANQUET—Ballroom—Memorial Union Building

Charles H. Lawshe Jr., dean of university extension services and professor of industrial psychology, Purdue University, Lafayette, Ind.

TUESDAY, OCTOBER 11

8:30 a.m.
SESSION 3A
Fowler Hall
Memorial Center

Session 3A

STATICS AND DYNAMICS IN 3-D MECHANISMS
Rudolf A. Beyer, visiting professor, Mechanical Engineering, Yale University, New Haven, Conn.

SPACE LINKAGE LAYOUTS ON A COMPUTER
D. W. Zawada, systems research department, Ford Motor Co., Dearborn, Mich.

SYNTHESIS OF PLANE MECHANISMS
Douglas P. Adams, associate professor of mechanical engineering, Massachusetts Institute of Technology, Cambridge, Mass., and Alexander Samoiloff, engineer, E. B. Badger Co., Cambridge, Mass.

8:30 a.m.
SESSION 3B
Room 214
Memorial Center

Session 3B

THE CARDAN POSITIONS OF A PLANE
Ferdinand Freudenstein, associate professor and chairman, Department of Mechanical Engineering, Columbia University, New York

INVERTED SLIDER-CRANK MECHANISM
George A. Bucci, design engineer, Servo and Mechanics Dept., Raytheon Co., Wayland, Mass.

SIX-BAR LINKAGES
A. C. Dunk, associate professor of mechanical engineering, Purdue University, Lafayette, Ind., and C. L. Hanson, mechanical engineer, Lawrence Radiation Lab., University of California, Livermore, Calif.

12:15 p.m.
LUNCHEON—Faculty Lounge—Memorial Union Building

ENGINEERING EDUCATION IN THE NETHERLANDS
W. L. H. Schmid, dean of mechanical engineering, Technological University of Eindhoven, Eindhoven, Netherlands

1:45 p.m.
SESSION 4—Fowler Hall—Memorial Center

PROSTHETIC MECHANISMS FOR LEG AMPUTEES
C. W. Radcliffe, University of California, Berkeley, Calif.

GENERAL DISCUSSION

Mail to: MECHANISMS CONFERENCE, Comptroller's Office (University Extension Administration, Room 110, Memorial Center), Purdue University, Lafayette, Ind. 233.105

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CONFERENCE REGISTRATION

The following persons plan to attend the Mechanisms Conference, October 10 and 11, 1960 (name and title, please):

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$_____ is enclosed for the registrations checked at $40 each. (Make checks payable to Purdue University.)

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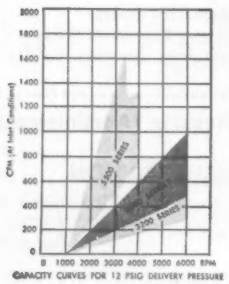
weigh only 625 lbs. Provide 400 SCFM continuous air flow



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M-D blowers operate at wider pressure and speed ranges than any other rotary positive blower. Capacities of 22 production models range from 50 to 4,000 CFM, pressures to 15 PSIG single, 70 PSIG multi-stage.

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Assoc., 27 East Monroe St., Chicago 3, Ill., $1.00 per copy.

Load ratings applicable to standard welded-steel conveyor pulleys, a list of pulley diameters considered standard for the industry, and a list of pulley face widths which are standard for the industry are tabulated. Several pages of data helpful in selection of proper pulleys are included.

Supplement to Third Edition of Drafting Standards—Aluminum Extruded and Tubular Products. *15 pages, 8½ by 11 in., paperbound, stapled; available from Aluminum Assoc., 420 Lexington Ave., New York 17, N. Y.*

This supplement contains revised, expanded, or new data concerning various standard tolerances for aluminum products. Structural shapes, extruded tube, drawn tube, pipe, and extruded rod and bar are included.

Government Publications

OTS Technical Reports. Copies of reports listed below are available from Office of Technical Services, U. S. Dept. of Commerce, Washington 25, D. C.

PB 151076. Heat Treatment of High-Strength Steels for Airframe Applications. By R. J. Fiorentino, D. B. Roach, and A. M. Hall, all from Battelle Memorial Institute; 111 pages, 8½ by 11 in., paperbound, side-stapled; $2.50 per copy.

In this survey, four steel producers and 24 consumers were polled to determine current heat-treating practices, applications, and problems. Seven classes of steel were surveyed. They include hot-work die steel, low-alloy hardenable engineering steel, cold-rolled austenitic stainless steel, martensitic stainless steel, and martensitic, austenitic, and semiaustenitic precipitation-hardenable stainless steels. Results are tabulated and discussed.

PB 161040. Thermal Conductivity of Lubricating Oils and Hydraulic Fluids. By D. W. McCready, The University of Michigan; 26 pages, 8¼ by 10¾ in., paperbound, stapled; $1.00 per copy.

Thermal conductivity of 12 natural and synthetic-base lubricating fluids was measured with an all-metal concentric-cylinder type of thermal-conductivity cell. Values of thermal conductivity for temperature range of 70 F to 500 F are reported for fluids considered stable at the higher temperature.

PB 161087. Combined Effects of Axial Load, Thermal Stress, and Creep in Flat Plates. By P. C. Huang and C. J. Van Der Maas, The Martin Co.; 131 pages, 8¼ by 10¾ in., paperbound; $2.75 per copy.

Methods for calculating stresses and strains in unevenly heated flat plates are presented. Methods are limited to analysis of loadings in the plane of the plate, and to temperature and strain distributions which are one-dimensional. Effects of plasticity, creep, and stability are considered.

Experiments using 2024-T4 bare aluminum plates are reported in detail.

PB 161338. Development of a Corrosion-Resistant Bearing Steel For Service in Aircraft at Temperatures up to 1000 F. By G. Steven and T. V. Philip, Crucible Steel Co. of America; 60 pages, 8¼ by 10¾ in., paperbound; $1.75 per copy.

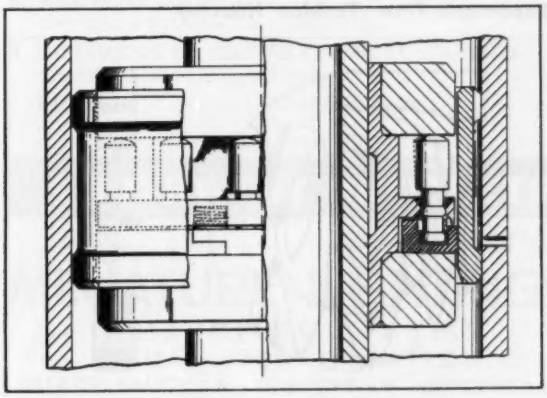
Corrosion resistance was added to the properties of high initial hardness, adequate temper resistance (600-900 F), and good dimensional stability of a high-speed type bearing alloy. Composition, heat treatment, and testing of the bearing alloy are discussed.

NOTEWORTHY

Patents

High temperature metallic joint between two thin metallic members, one of which is a porous matrix, is made by a brazing process. Among the materials recognized as suitable for the porous matrix is 99.8 per cent nickel and 0.2 per cent silicon. ASTM cathode alloy, grade 21, is listed as a suitable second metal. A braze material of nickelic oxide known as B-10 serves as the binder. *Patent* 2,945,295 *assigned to Westinghouse Electric Corp., East Pittsburgh, Pa., by Gene R. Feaster.*

Centrifugally-Compensated Seal



Lever-pins at high rotative speeds counterbalance the effects of centrifugal force on a seal to prevent excessive peripheral pressures between the seal and its housing. The pins are fulcrumed in a rotating ring assembly. The tendency of the heavy end to move outward under centrifugal force produces an inward force on the seal. The seal is divided transversely to allow adjustment according to the forces acting upon it. *Patent* 2,943,873 *assigned to General Electric Co. by Clarence Lockwood Hamm and William Widlansky.*

Interval timer provides pushbutton initiation, preselection of timing cycle, an indicator for the unused portion of a cycle, and for shortening or lengthening a cycle after initiation. The timer is electrically driven and controlled. *Patent* 2,943,159 *assigned to General Time Corp., New York, by Carl J. Goodhouse and Christian M. J. Jauch.*

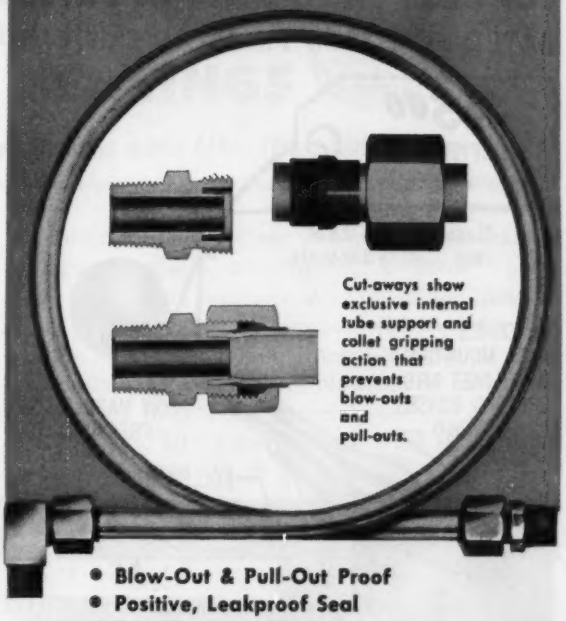
Magnetostriction Relay

Change in length of an armature when subjected to a magnetic field makes-and-breaks electrical contact in small relay. The armature, normally bowed, contracts upon excitation of the magnetic coils that

FLODAR

SELF-LOCK

FITTINGS FOR PLASTIC TUBING



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- Positive, Leakproof Seal
- Easy To Assemble
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The new line of FLODAR ***SELF-LOCK*** fittings guarantees safe, reliable nylon and other plastic tube systems. This unique line of fittings can be used on any fluid system — hydraulic, pneumatic lubrication, instrumentation or chemical processing.

Two exclusive ***SELF-LOCK*** features assure protection against blow-outs and pull-outs:

Internal Tube Support — prevents collapse of the tube as the fitting is tightened.

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SPECIFICATIONS

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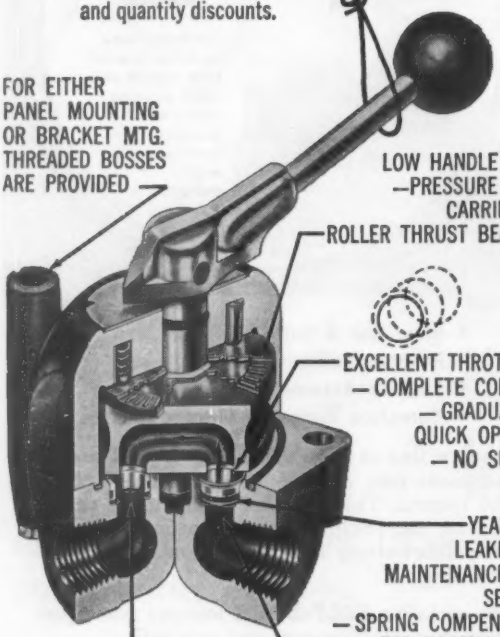

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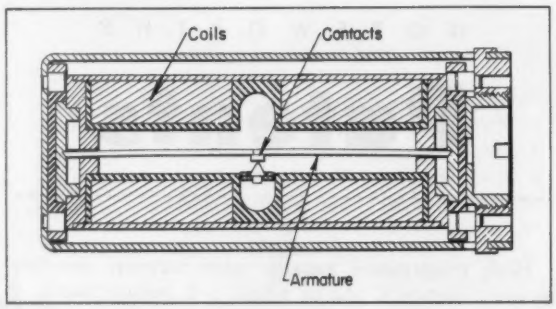
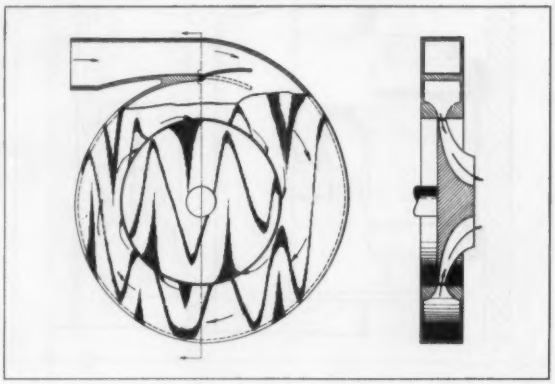


surround it. When the coils are energized by direct current, the armature contact remains closed or open as the field coils are energized or de-energized. When the coils are energized by alternating current, the armature makes-and-breaks contact at the ac frequency. *Patent* 2,945,105 *assigned to Nobles Engineering and Manufacturing Co., Ramsey County, Minn., by Ward H. Ingersoll.*

Supersonic-Flow Turbine Housing



Accessory drive turbine uses a housing of logarithmic-spiral form to operate at either subsonic or supersonic fluid inlet speeds. Incoming fluid, regardless of speed, is guided into vortex flow and contacts the turbine blades at angles established to permit transition from subsonic to supersonic speeds of flow without serious loss of efficiency. An adjustable vane controls the quantity of incoming fluid with a minimum of throttling action. *Patent* 2,944,786 *assigned to Thompson Ramo Wooldridge Inc. by Pierce T. Angell, Robert J. Anderson, and Malcolm M. Hopper.*

Surface temperature is sensed for measurement electrically by a conductive wire or mesh, as platinum. Preferably the wire interlaces a grid support. The wire and the support are bonded to the body surface by a cement of nonmetallic composition, such as fused quartz, or mica. *Patent* 2,944,236 *assigned to Engelhard Industries Inc., Newark, N. J., by Edward P. Anderson.*

Copies of patents briefed in this department may be obtained for 25 cents each from the Commissioner of Patents, Washington 25, D. C.

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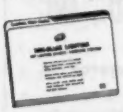

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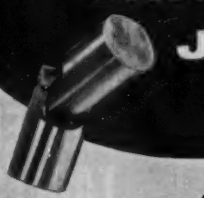

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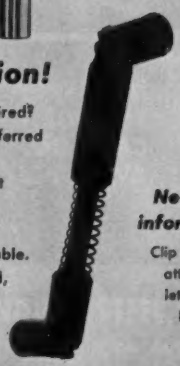

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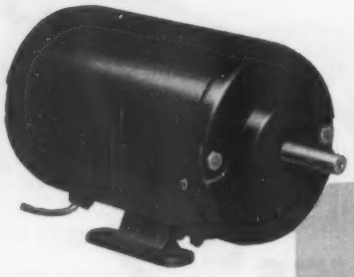

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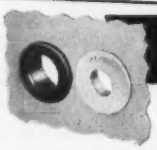

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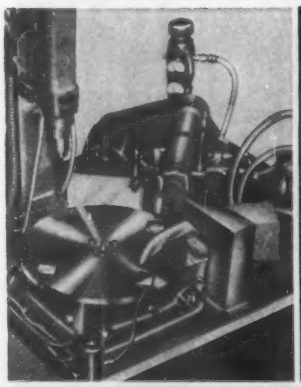

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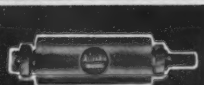

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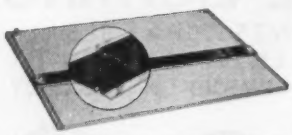

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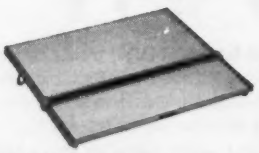

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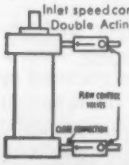

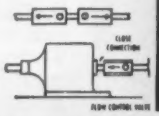

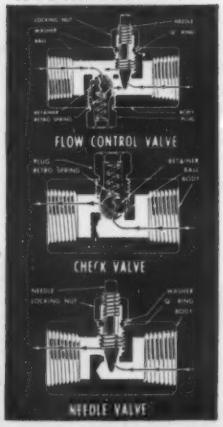

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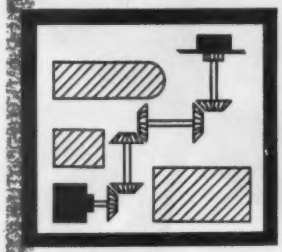

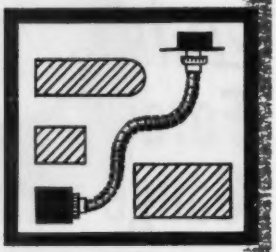

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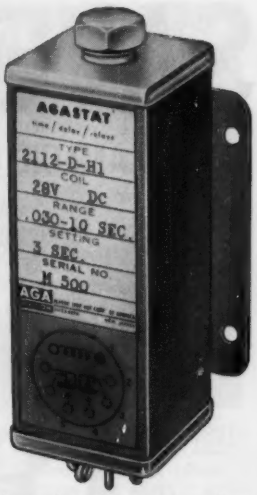

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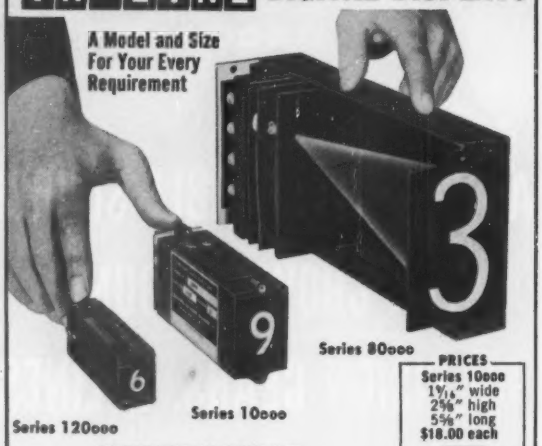

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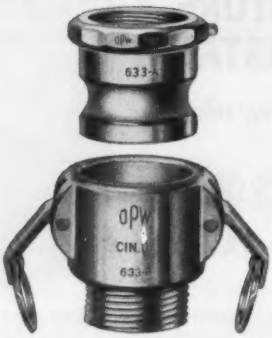

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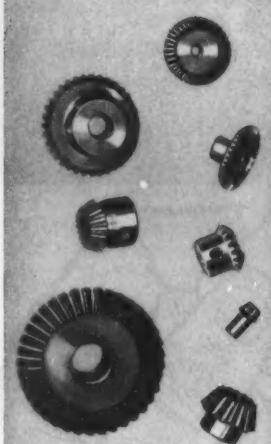

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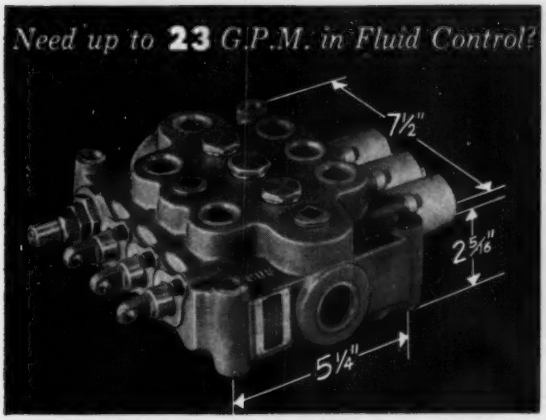

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Unimax K-series LIMIT SWITCH

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- Long life
- Easy wiring
- Wide-range adjustability

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20 amperes
125/250/480 v. a-c

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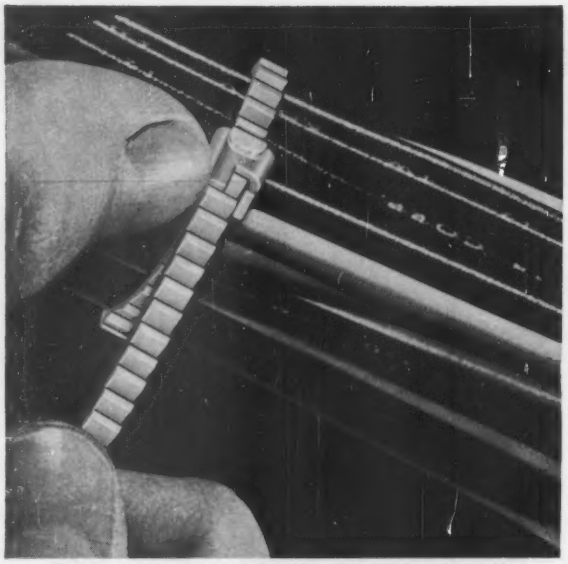

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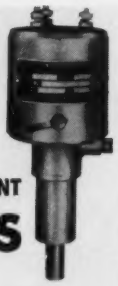
SPEED SENSITIVE



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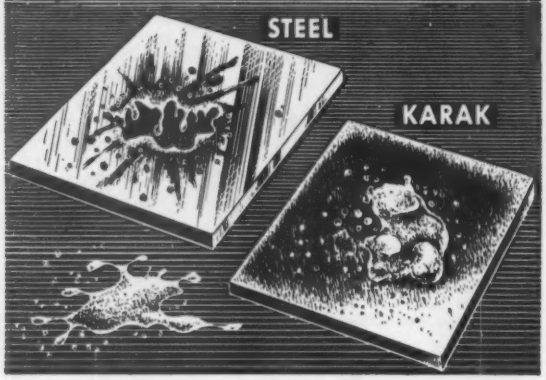

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5,000 degrees generated within a fraction of a second, couldn't crack or chip KARAK...exerted no effect other than slight oxidation of the surface.

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Let FUNK solve your power transmission problem.

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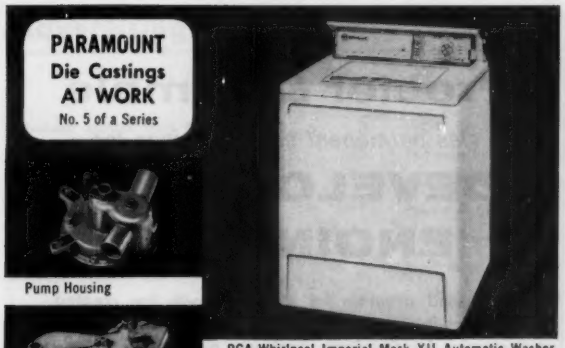
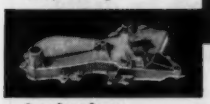
Die Castings
AT WORK
No. 5 of a Series



Pump Housing



Gear Case Cover

Filter Handle

RCA-Whirlpool Imperial Mark XII Automatic Washer

PARAMOUNT—a major supplier of die castings to Whirlpool Corporation for 15 years

Whirlpool quality is recognized throughout the world, quality which stems from the rigid quality standards which Whirlpool demands that its suppliers meet.

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If your product incorporates die castings or you're considering them—investigate Paramount's complete services.

Three complete plants—two in St. Joseph, Mich., one in Seymour, Indiana.

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PARAMOUNT *Die Casting Co.*

(A subsidiary of TALON, INC.) ST. JOSEPH, MICHIGAN

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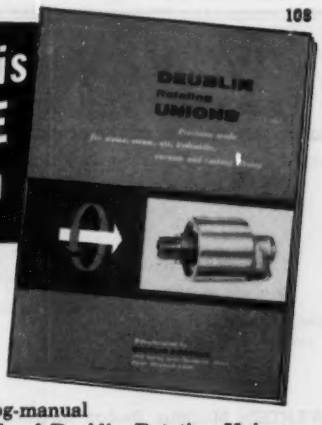

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Write for your free copy today.

DEUBLIN COMPANY

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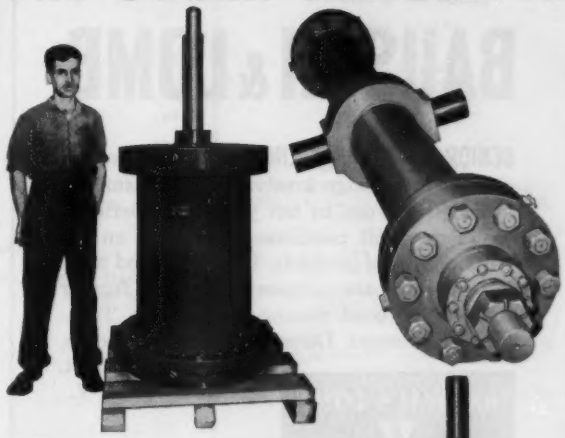
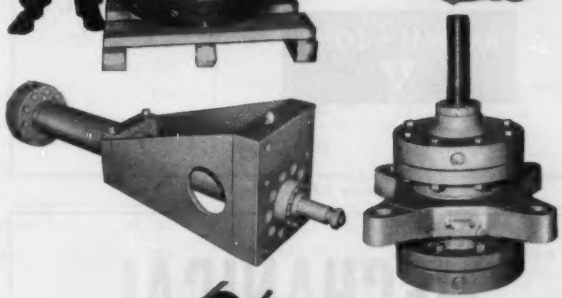
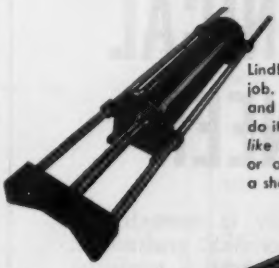
ANY SIZE OR SHAPE . . . THE ODDER THE BETTER







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LINDBERG AIR and HYDRAULIC DIV.

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Subscription in United States, possessions, and Canada for home-addressed copies and copies not qualified under above rules: One year, $10. Single copies $1.00. Other countries: One year, $25. Published every other Thursday by The Penton Publishing Co., Penton Bldg., Cleveland 13, Ohio. Accepted as Controlled Circulation publication at Cleveland, Ohio.

BPA NBP

backtalk——

—Inside Machine Design

Assistant editor Richard A. Jacobson, who answers when we call either Dick or Jake, is an Engineering News-hound for MACHINE DESIGN. Born in Chicago, Dick came to Cleveland by way of New York. He enrolled at Fenn College and earned a B.S. in engineering physics. Fenn is a co-operative school, and Jake spent his work periods as a draftsman and doing research. He also taught physics as a student instructor. After receiving his degree, he worked briefly as a mathematician, then joined the American

Gas Association as a research engineer. We got him in April of last year.

For relaxation from the hectic publishing business, Jake goes home and watches his turtles. He keeps a bunch of them in a tank so that he can observe them because (he insists) they are such fascinating creatures. Our Richard is also a mean chess player—he spends many a happy lunch hour trouncing a fellow editor.

—Power from Above

Various and unusual tools are often used for ground-breaking ceremonies. A combination that rates high in appropriateness was employed at the site of the new scientific research center to be built by Nortronics Div. of Northrop Corp.: First ground for the $4 million center was turned by an old-fashioned walking plow, pulled by a helicopter.

—Shop Talk

While browsing through the booklets offered in our August 18 Helpful Literature columns, we paused to spend a few minutes with "Do You Talk 'Computerese'?" This is a glossary of "the wondrous language of the computer engineer" prepared by the Industrial Div. of Minneapolis-Honeywell Regulator Co.

A non-Computerese-speaking person will read with amazement the definitions of such down-to-earth words as block, gate, housekeeping, and patch, as well as the jazzier expressions: Double precision arithmetic, nixie light, peripheral equipment, pseudo-code.

Cartoons appear throughout the booklet. We especially like the one of a young scholar surreptitiously consulting a paper inside his desk during a quiz. This, of course, illustrates an *external memory*.

E. A. Murphy Jr., a staff editor of M-H's *Instrumentation* magazine, prepared the glossary. He has provided a painless way for anyone to learn—or brush up—his Computerese.

—Man with a Good Line

Our recent news releases included one that will warm the cockles of any standards advocate's heart—it concerns the awarding of the U. S. Dept. of Commerce Silver Medal for Meritorious Service to Mr. Benjamin L. Page. Mr. Page is chief of the Length Section of the National Bureau of Standards, which means that he is in charge of the laboratory that keeps the national standard of length. He was cited for "development and successful application of techniques for achieving the highest accuracy and reliability in intercomparison and calibration of line standards of length."

Mr. Page has been at NBS since 1918, the year he graduated from college with a degree in physics. His work has been to increase the accuracy and precision of length measurements, and he has done it well. In 1946 he received an award for graduation of (at that time) the most precise theodolite circles in the world, and an NBS Superior Accomplishment Award was bestowed upon him in 1955 for his recalibration and intercomparison of the Bureau's length standards with the highest attainable precision and accuracy.

We congratulate Mr. Page for all his achievements and urge him to hold that line.

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U.S. Pat. No. 2810594

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1—Coupling and hose end virtually molded together by three-way locking arrangement—will hold for life of hose.

2—Ferrule design actually protects hose against failure due to continuous flexing at back of coupling.

3—Exceptional strength and durability of the "Holedall" precludes possibility of blow-offs under extremely high working pressures.

4—Streamlined—no projecting parts to snag—easily installed in very close quarters.

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"MULCONROY *Starts...* WHERE OTHERS *Stop!*"

MULCONROY CO.

Hose Specialties Since 1887

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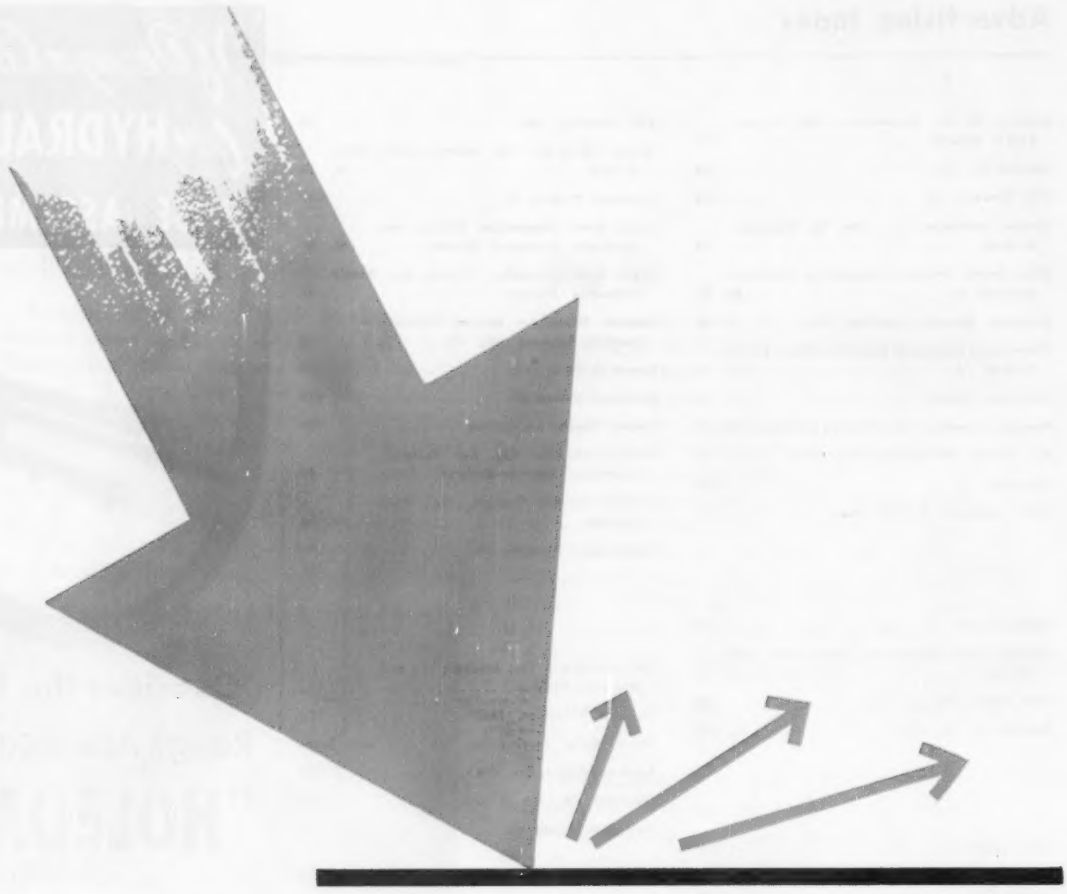

Metallurgical Phenomena... and the metals to cope with them.

These are the stock-in-trade of the Lukens Application Engineer—whether the problem be one of abrasive impact (symbolized above) or corrosion or pressure or structural stress or high and low temperature. Investigation of the best steels for "problem" applications has been carried on for years by the Lukens Application Research team. We would welcome the opportunity to contribute the results of this research to your own design knowledge. Please contact us in your early design stages. Call collect: Joe Proctor, Manager of Application Engineering, Extension 422, Lukens Steel Company, Coatesville, Pennsylvania.

HELPING INDUSTRY CHOOSE STEELS THAT FIT THE JOB

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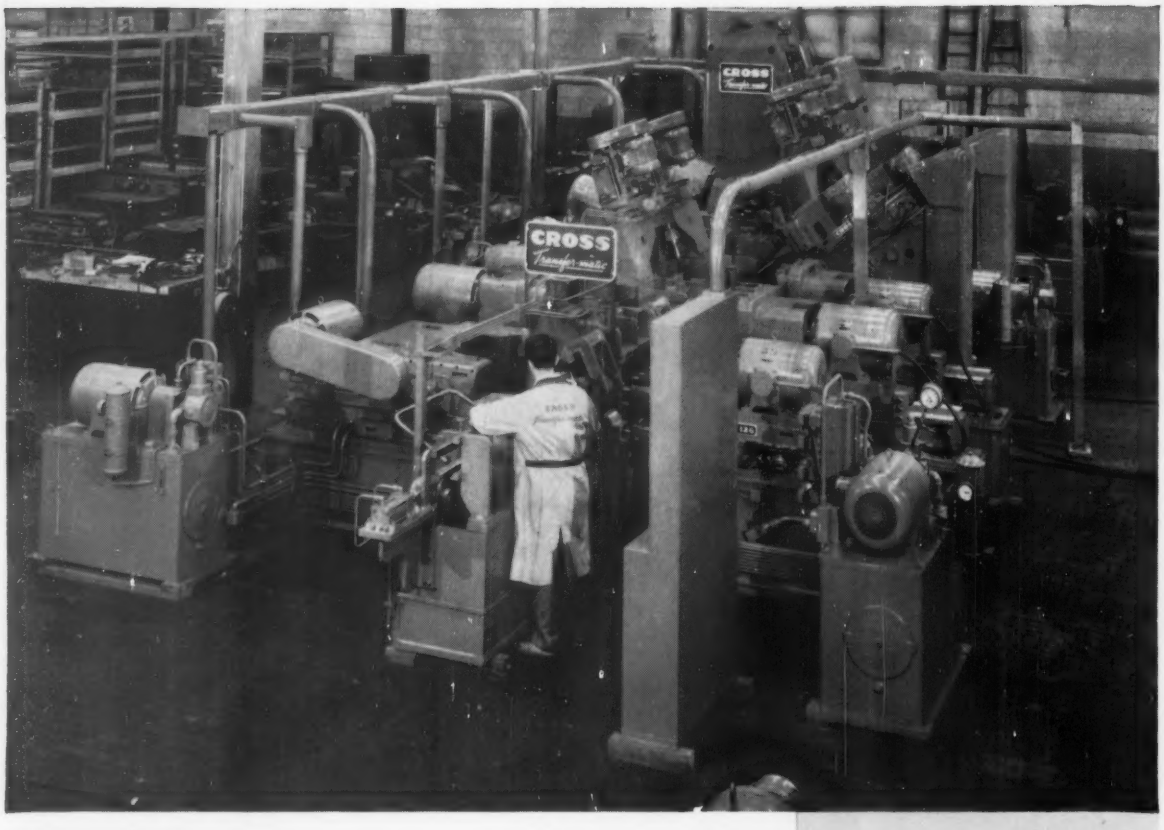
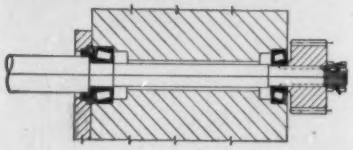


Why Cross chose Timken® bearings for all 148 drill spindles

How **THE CROSS CO.** mounts 148 drill spindles of its Transfermatic on Timken bearings to give longer bearing life, maintain accuracy.



THIS huge Cross transfer machine drills and taps holes in automobile engine blocks at new highs in speed and accuracy. To assure maximum user economy and machine life, Cross engineers chose Timken® tapered roller bearings for the machine's 148 drill spindles. Here's why:

1) *They maintain precision longer.* Timken bearings are geometrically designed to give true rolling motion, precision manufactured to live up to their design.

2) *They're extra tough* because Timken bearings are made of the finest bearing-quality alloy steel available.

When you use a machine with Timken bearings, you get all the *extra* benefits of Timken Company leadership in tapered roller bearing design and in engineering service. We maintain the industry's most modern laboratory to test bearing applications. To get better machines, make sure they're Timken bearing-equipped. ***When you buy Timken bearings you get...*** 1) *Quality you can take for granted.* 2) *Service you can't get anywhere else.* 3) *The best-known name in bearings.* 4) *The pace setter in lower bearing costs.* The Timken Roller Bearing Company, Canton 6, O. Cable: "TIMROSCO". *Makers of Tapered Roller Bearings, Fine Alloy Steel and Removable Rock Bits.* Canadian Division: Canadian Timken, St. Thomas, Ontario.

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